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6th ed.

THE MANUAL OF PHOTO-TECHNIQUE



THE MANUAL

OF PHOTO-TECHNIQUE

Edited by A. KRASZNA-KRAUSZ

DEVELOPING

THE NEGATIVE-TECHNIQUE

By C. I. JACOBSON, Ph.D.

Sixth Edition

THE FOCAL PRESS

31 Fitzroy Square, London, W.
381 Fourth Avenue, New York

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First Edition : May, 1940

Second Edition : May, 1942

Third Edition : Dec., 1943

Fourth Edition : Aug., 1944

Fifth Edition : May, 1945

Sixth Edition : April, 1946



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Printed 1946 in Great Britain by W. & J. Mackay and Co., Ltd., Chatham,
for The Focal Press Ltd., Fitzroy Square, London, W.1.

I. *THE MANUAL OF PHOTO-TECHNIQUE* presents in this volume an exhaustive survey of modern negative technique and a comprehensive collection of the formulae used in its practice.

Considerable research work has been done in sifting, testing and improving those numerous suggestions which only too often are passed on from text-book to text-book without further scrutiny. A number of hitherto unknown or unpublished formulae have been added.

No effort has been spared to help the reader to benefit from this material—in spite of its vastness. He is shown which particular formula he should choose and how to apply it to secure a given photographic effect, a certain technical quality, and how to do this as economically as possible. The first and last ambition of this volume is to be of use in practical work.

II. The second edition of this book follows the first after less than two years. Measured by the speed of research work, this is but a short interval. Still, and in spite of the war, photographic progress marches on and the number of formulae in this book grew to nearly 200, although we tried to economise both with our space and the readers' time. Once more it was thought wise to disregard patent mixtures with glamorous claims, which from time to time invade the market.

III. Entirely new is the chapter devoted to substitute chemicals necessitated by war-time shortages.

IV. Added to this fourth edition is a short critical survey of formulae as recommended by leading manufacturers.

V. The fifth edition has been carefully revised. Obsolete formulae have been dropped, others brought up-to-date, some new ones included. A number of theoretical passages have been further clarified and a few of the diagrams re-cast.

VI. In this sixth edition, account has been taken of the latest researches into fine grain development.

A. KRASZNA-KRAUSZ.

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LIST OF FORMULAE

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DEVELOPMENT : WHAT IT IS AND WHAT IT DOES

If we expose a photographic plate or film in the camera the closest visual examination fails to disclose any perceptible change in the sensitive coating which, in general, consists of a suspension of silver bromide in gelatine and to which the name *emulsion* is given.

Yet we all know there has been a change and that the application of a developer will reveal it. We say that the action of the light on the sensitive material has produced a *latent image*. Latent here means unrevealed or undeveloped.

The development of this latent image by means of the developer is one of the most important and interesting of all photographic processes, and upon its successful operation depends in very large measure the nature of the end product, that is, the finished photograph, which is our goal.

In order to render the latent image visible we make use of certain substances known as developers, which have the property of changing the exposed *silver bromide* into black *metallic silver*. Hence we think of two processes, first a photochemical change brought about by light during exposure, second a chemical change by which the exposed silver bromide, that is the latent image, is changed or reduced to metallic silver and so rendered visible.

This second process is called *reduction* by the chemists.

If we were to introduce an unexposed plate or film into the developer at most a very small amount of silver bromide would be reduced to silver. So we see that only the exposed silver bromide responds to the action of the developer and is reduced or changed to metallic silver.

It is most important to notice that those parts of the sensitive emulsion which received most light provide the heaviest deposits of reduced silver and are therefore

blackest, whereas where only a small quantity of light acted on the silver bromide the amount of silver reduced is much less. If we examine the result very carefully we find that the amount of reduced silver is larger the larger the amount of light which acted on the sensitive material.

The Negative

This gives us a very interesting result: we have now got a developed picture in which all the light values of the original object photographed are reversed. The lightest parts of the original are darkest in our picture while the dark parts of the original are light in our result. That is why we call the result a *negative*.

This reversal of light values must always be borne in mind if we are to understand rightly the process of development and to read our negatives correctly.

We remember then that *the darkest parts of the negative represent the lightest parts of the subject photographed*, therefore the high lights of our subject provide the blackest areas in our negative.

Also *the lighter parts of the negative represent the darker or less well-lit areas in our subject*, hence the shadows of our subject provide those areas in the negative where the lightest deposit of silver is or perhaps not even a light deposit, but clear gelatine.

Development : A Reduction Process

We have already seen that photographic development is a reduction process in which the developer acts as a reducing agent. But photographic developers are quite a special kind of reducing agent, because they act only on silver bromide that has been exposed to light.

The chemist knows many reducing agents capable of reducing silver bromide to metallic silver, but they act quite differently to the photographic developer for they fail to discriminate between silver bromide which has been exposed

to light and that which has not, so that a plate or film placed in such an agent would be completely blackened irrespective of whether one part had been exposed or another part unexposed.

Just why the photographic developer reduces only the silver bromide that has been exposed to light is a question we do not propose to answer in this book, for our interests are purely photographic, and a discussion of the many physico-chemical problems involved would not necessarily increase our understanding of the essentials of photographic development.

Chemical and Physical Development

One small chemical point we must know is that in the process of reducing silver bromide to silver, *bromine is set free and passes into the developer solution* in the form of a bromide salt. This is an integral part of the reduction process and is of importance because it can, under certain circumstances, cause various troubles.

In such a development process as we have described it is clear that the silver which builds up the image in the negative is derived from the sensitive film of emulsion on the plate or film, and that it is produced by the chemical reduction of the silver bromide.

We therefore call this process chemical development, to distinguish it from another process, called physical development, in which silver, already present in solution in the developer, is deposited on the latent image, a method which might be likened to silver-plating.

The composition of the developer and the method of development can naturally influence the character of the negative produced, and by suitable methods it is possible to exercise a large measure of control in our development processes. To do this with some degree of confidence it is necessary to understand something of the properties of the sensitive materials.

IMPORTANT PROPERTIES OF SENSITIVE MATERIALS

The following properties of sensitive materials are of particular importance in relation to the development process:

- (1) *Sensitivity.*
- (2) *Gradation.*
- (3) *Grain and Graininess.*
- (4) *Resolving Power.*
- (5) *Halation.*

Sensitivity

In choosing photographic material the question of sensitivity is naturally of first-rate importance, but it would be a mistake to think that it was the only criterion, for example *it would be wrong to think that the fastest, or most sensitive, film was necessarily the best.* Other properties such as graininess may well play an important part and influence the final result quite as much.

On the other hand, if we have chosen the fastest and most sensitive film, then we want to feel that we know just how to develop it so that we do not lose in the processing of it just those qualities which the manufacturer has been at such pains to confer upon it.

Comparing the Sensitivity of Two Films

We may desire to compare the sensitivity of two films, one with another, and a quite simple experiment will enable us to do this, and also to understand and investigate other properties of the sensitive material. We start from the definition that *a film of high sensitivity is one requiring a small exposure to light, or to put it in another way, a small light impression, in order to produce on development a given degree of blackening beyond that produced in an unexposed area, which latter is known as "fog."*

We take two strips of the films we wish to compare and arrange them so that by moving an opaque card or other cover we can expose successive areas on the two strips, to a light source such that a reasonably long exposure is necessary to produce full blackening of the exposed film-strips when developed. We now expose them by moving the opaque card so that successive portions of the film receive exposures double the time of the previous exposure, for example, 1, 2, 4, 8 seconds, and so on.

In this way we shall obtain what we can call *blackening scales* (see page 25) for the two films when we have developed the strips.

We shall note that the two strips differ in the position occupied by the first visible trace of reduced silver, the faster film, for example, may show it at 1 second, while in the slower film it may not appear until the step is exposed for 4 seconds.

But that is not all that we can learn from our strips; we can also gather that in those parts of the film which have only received a small exposure to light a certain length of time of development is essential if we are to obtain the full blackening due to the exposure, and that if the time of development be cut short then the effect of small exposures to light will be lost and we shall also lose some of the advantage of using a fast film.

To put this another way, if a film is under-developed shadow detail is lost (see page 27); in fact, the film which is developed for too short a time behaves as if it were much less sensitive than is actually the case. Hence we see that the *time of development is of great practical importance* and has a real influence on the practical sensitivity of our material. If we desire to utilize fully the whole sensitivity of our material we must develop it completely.

We can extend our experiments with strips of sensitive material and use different developers, or we may use developers of the same composition but vary the tempera-

ture of development, and we shall find that all these factors are capable of influencing the result.

Measurements of Sensitivity

Our experiments have introduced us to the rudiments of sensitivity measurements ; it is important to bring out a few of the essential requirements necessary when undertaking sensitometric investigations.

(1) A *Light-source* of such a character as to permit of *constant and controllable light output* so that identical conditions of exposure can be repeated time after time. Moreover, as in the great majority of cases it is the sensitivity of materials to daylight that we are interested in, we must ensure that our light-source provides light of such colour composition, or spectral composition as it is called, that it approximates closely to daylight. Such a source is a tungsten filament, gas-filled lamp fitted with the necessary control of electric current to maintain a constant light output.

To this must be added a *filter which shall transmit light of almost exact daylight-quality*. For the photographer who desires to make a few measurements now and again it will be sufficient to use one of the filters supplied for transforming half-watt light to daylight. This filter is fixed in a frame in front of the lamp house carrying the tungsten filament lamp. This daylight filter should not be the gelatine film type, as these are liable to change in time and with use, the daylight filter should be the all-glass type which is permanent and unaffected by age or use.

A light source and filter as described can be used for determining the sensitivity of any photographic material, whether ordinary, orthochromatic or panchromatic, and is particularly useful for comparing the relative sensitivity of materials in general use with new productions or with materials which have not hitherto been in common use.

(2) An *exposure machine* or apparatus. This takes the place of the opaque cover used in simple experiments and may consist of a wedge scale of blacknesses, or, as is more usual and convenient, a *step wedge in which the relation of the density or blackness of the steps to one another is known*. Another method is to make use of a sector wheel which has been so cut as to provide a range of accurately determined exposures during a single revolution. For simple measurements the step wedge is recommended as being the easier to obtain and costing less than more elaborate apparatus.

Whichever type of exposure apparatus is used, the effect is to produce a graded series of exposures on the sensitive material being tested. These exposures always bear a constant relation to one another and the only factor the operator has to watch is the control of the light source. This should be arranged at such a distance from the exposure apparatus that an exposure of, say, ten seconds suffices for a very wide

variety of sensitive materials. The reason for choosing an exposure of ten seconds is that an error of one-tenth of a second in switching the light on or off will mean only a one per cent error in exposure, whereas if the exposure time were only one second the same error would be ten per cent and therefore serious.

(3) *Developer for the test-strips.* This is of the utmost importance and calls for careful consideration if only because the relation between sensitivity and development is the biggest factor involved in the actual technique of development. We have already seen that development can affect the result of any determination of sensitivity, for if we do not develop fully, then the sensitivity of the material being tested will appear to be lower than it really is. Hence if we are to obtain comparable results our methods of development must be most carefully controlled, so that they not only give comparable but also reproducible results. That means a *developer of definite composition, used for a definite time at a definite temperature*, with a well defined method of agitation. We may decide to use a reasonably energetic developer for such a time and at such a temperature that we know the strips will be fully developed. Or we can use a particular developer to attain a pre-determined gradation (see page 33), but whatever method we use must be capable of giving identical results with identical materials as many times as we desire, and that is not the simplest thing in the world.

(4) A means whereby we can *measure the degree of blackening on our developed strips*. This should be some form of comparator in which the density or blackening of the developed strip is compared visually with a standard wedge of known densities and gradation. There are various types available, but it is quite beyond the scope of this book to discuss or describe them.

In determining or measuring sensitivity, and particularly in comparisons between different materials, a most important criterion is the smallest perceptible blackening which the exposure has caused, or to say it in another way, the smallest light effect which is developable on our test strip. It is particularly important that we should be able to measure this accurately, and we want also to remember that we are not dealing with the least perceptible blackening that the eye can detect; what we are considering is blackening or *density which is capable of being copied when we make a print from our negative*. That is the practical side of the question, and to-day we are much more interested in a threshold value that we can reproduce in our print than in some faint deposit just perceptible to the eye but which is without influence in reproducing a negative in positive form and is therefore outside the useful sensitivity of our material.

If we study the various methods of determining and expressing the sensitivity of photographic materials, such as the *Scheiner, D.I.N. and Hurter and Driffield (H. and D.)* systems, we shall find that threshold value plays an important part, but also that in the modern view it is not the first

perceptible trace of light effect that counts, but the lowest density capable of reproduction when the negative is printed.

Now we must leave questions of sensitivity to discuss those other properties of photographic materials which are of importance to us in considering development and particularly the way in which they can be affected or influenced by it.

Gradation

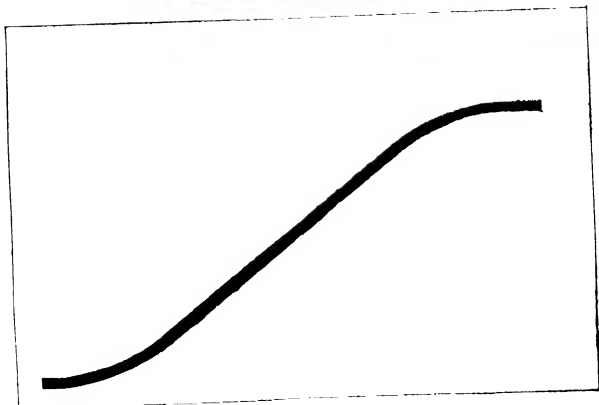
Our experiment in exposing strips of film to produce a graded series of exposures provides us with a means of investigating a very important property of sensitive materials, namely gradation, and of understanding how this is related to or affected by development. In order to do this we have to consider the whole range of our strips and not merely one or two of the steps or exposures on our scale of blackening.

When we do this we can see just how any particular sensitive material reacts to a graded series of exposures, so arranged that they bear a constant ratio to one another. Such a scale of blackenings or exposures indicates what we call the gradation of any particular material, and they can be of very different character as we shall see.

For example, the film (on page 25) has a long range of steps between the deepest black and the lightest deposit, whereas on page 26 there are only a few steps over the same range. We call the first a *soft gradation film*, and the second we designate as *hard*. Between these two extremes there may be many different degrees of gradation and particularly that which we should call *normal*.

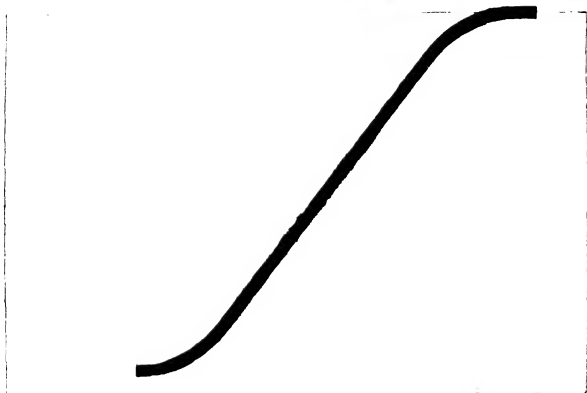
Blackening Curves

These terms soft, normal, hard, etc., have no exact significance, they are relative and only take on a quantitative value when used in comparing properly prepared blackening



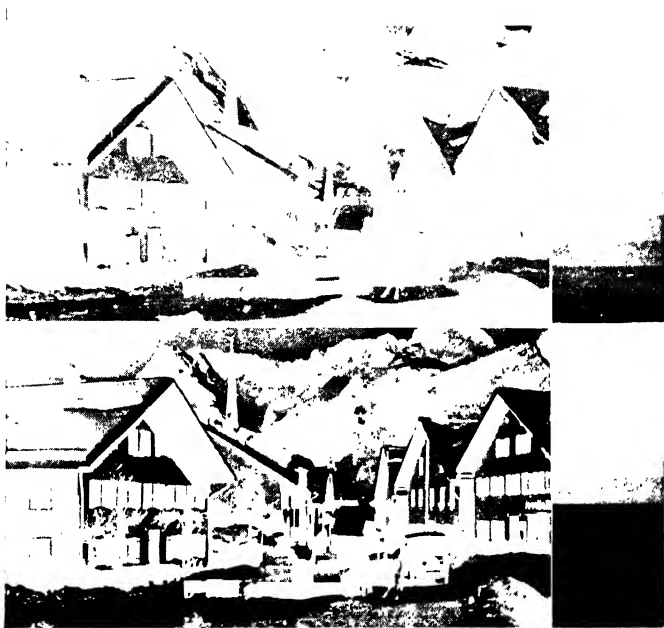
SOFT GRADATION

The scale of gradation is long and comprises a wide range of densities which build up the above soft negative. It will be seen that the fairly long blackening curve does not rise at a high angle, hence the gamma value is (see page 30) not high.



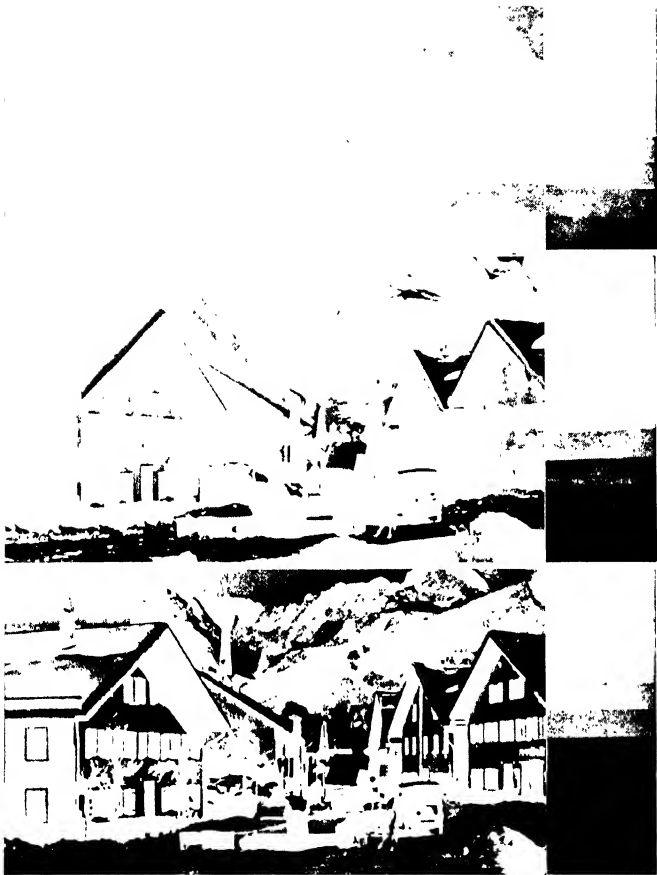
HARD GRADATION

If this negative is compared with that on page 25 it will show the difference between a soft and a hard negative. In the latter the scale of blackening is short and the curve is steeper, hence the gamma is higher. The curve also rises much higher, hence the negative has higher or greater densities particularly in the high lights.



PROGRESS OF DEVELOPMENT IN A RAPID DEVELOPER

In such a case the image develops so that all the details, shadows as well as high lights appear almost at the same time (*top*). As the development proceeds, density grows all over and hence a strong and contrasty negative is seen (*centre*) until finally the required contrast is reached (*bottom*).—See page 34.



PROGRESS OF DEVELOPMENT IN A SLOW DEVELOPER

Here two high lights appear first (*top*), then the middle tones (*centre*) and finally the shadows (*bottom*). The negative builds up slowly from the first appearance of the high lights to the final filling up of detail in the shadows, by which time it has the necessary gradation and density.— See page 34.

curves of sensitive materials. The average photographer is rather repelled by curves and mathematical formulae, yet the expression of properties by a curve is a tremendous help in visualising clearly a collection of observations and is infinitely easier to read and understand than are columns of figures. We have only to think of the ease of handling statistics of a recurrent character over any period of time to realise that a moment's glance at a curve can convey information which otherwise might take minutes or even hours.

So if we desire to visualise the relation between the exposure to light and the blackening it produces on sensitive material, the simplest way to do it is to produce a curve, and if we wish to compare more than one material then we simply build the curves on the same diagram.

Up the side of the diagram (see p. 31) we plot units of *density* or blackening. The definition of density and the method of measuring it are indicated in the insert of the diagram. If we let a beam of light of intensity I_1 fall on to our photographic density D , the intensity is reduced to a value I_2 . We call our density one where it reduces the measuring light intensity to 1/10th, two, where it reduces to 1/100th, three, where it reduces to 1/1000th, etc. Thus on our *density* axis we allot *equal decrements* of the intensity I_2 to a *density unit*, for example, if any two densities differ from one another by the lighter density transmitting twice as much light as the heavier one, the spacing between these two densities will be constant (and equal to 0.3) whatever the actual values of the densities may be. (For the mathematically minded it will be clear that we are defining density as the logarithm of the ratio of transmitted to incident light intensity.)

Along the base of the diagram we have *divisions* which represent *equal increments* of exposure intensity. The exposure increment axis is very similar to the density axis in that *any two exposures* which are in a *certain ratio* to one another (as for example 2 to 1) are spaced a *constant*

distance apart on the increment axis (in this instance 0.3). (Again the mathematically minded will notice that we plot the characteristic curve on a logarithmic intensity axis.)

Now the curve itself is obtained from a series of measurements of densities which have been produced by certain exposures. On the axes described we erect verticals at corresponding values of density and exposure ; where these verticals cross we have the points of the curve. In this way we can build up and compare the blackening curves for different materials.

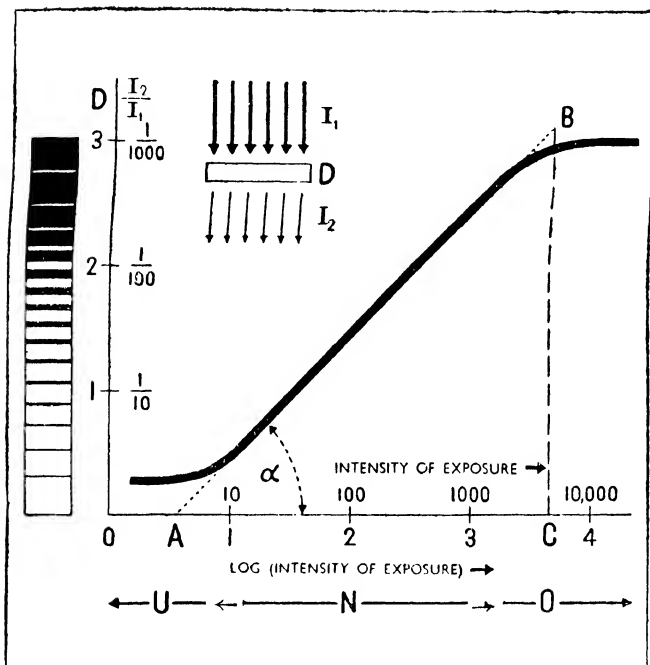
On pages 25-26 we have the two curves of the strips of two films that we have already spoken of, and at once we see how great a difference there is in their gradation.

In order to understand more thoroughly how to read and interpret such curves, let us consider first of all the straight line portion of the curve on p. 31. Here, on increasing the exposure by, for example, ten times, the amount of light transmitted by the developed density drops to one tenth since the curve rises at an angle of 45° to the axes ; this is correct whichever exposure we start from as long as we stay on the straight-line part of the curve. In this case we speak of a correct reproduction in densities of the varying quantities of light forming these densities.

Now the actual characteristic curve is straight over but a limited range of exposures and densities. The curve bends both at the lower and the top part. With any complete characteristic curve there comes a point where increasing exposure does not increase the density. Thus at the top end of the curve is situated the *region of over-exposure*.

In the same way at the beginning of the curve there is a region where exposure to light causes no change in the density, followed by a region where density increases more and more rapidly with increasing unit increments of exposure—until the straight-line part is reached. The very lowest part of the curve is the *region of under-exposure*.

The most usual normal exposures reach from somewhere



THE CHARACTERISTIC CURVE AND THE GAMMA

The characteristic curve of photographic material is a plot of density against the logarithm of exposure necessary to produce that density on development. Density is defined as the logarithm of the incident light divided by the transmitted light intensity; $D = \log I_1/I_2$, I_1 and I_2 being the intensities illustrated in the insert diagram. The values of the ratio of I_2/I_1 are shown against the density values D , and similarly the exposure intensity values are shown against the log exposure in order to illustrate the logarithmic relationships. The region of under-exposure is indicated by U, that of normal exposure by N, that of over-exposure by O along the exposure axis. Gamma is a figure which expresses the contrast of a negative. It is measured or determined by protruding the straight-line part of the curve until it meets the horizontal axis at A and a vertical axis erected at a point B anywhere along the exposure axis. Then gamma is $\tan \alpha = BC/AC = \gamma$. In the above example gamma is 1, for the angle α is 45° and so AC and BC are equal.

in the lower bent portion of the curve well into the straight-line portion. The region of *normal* or correct exposure may be said to reach *from halfway up the lower bent part of the curve all the way up the straight-line part.*

Looking now at the two curves on pages 25-26, we can see that there is a notable difference in their slope and therefore in the angle which their straight-line portion makes with the horizontal axis or base of the diagram. Moreover, we notice that neither curve fulfills the ideal condition of being a straight-line at an angle of 45° to the horizontal axis and in this respect they differ from the curve on page 31. The curve of the soft gradation film A makes a much smaller, that of the hard gradation film B a much larger angle with the axis.

Gamma

Now this angle which the curve makes with the horizontal axis is very important because it is the basis of that famous value *Gamma* (γ) which so often occurs in photographic literature and which, unfortunately, is often but little understood. Gamma might be defined as the unit by which we measure the gradation of photographic material.

If we desire to give it a more accurate definition we say that Gamma is the tangent of the angle produced when the straight line portion of the blackening curve is prolonged to meet the horizontal axis. It will be obvious that *as the curve is steeper or less steep, so the angle will vary and so, too, the Gamma*, and that the Gamma will vary directly with the steepness or otherwise of the curve and therefore with the gradation.

Gamma, or the tangent of the angle, is measured as follows. On page 31 the straight line part of the curve is prolonged to A, where it cuts the base, and to B where it meets the vertical side of our diagram; at the bottom of this vertical is point C, where the horizontal and vertical axes meet. Now the tangent of the angle a is the ratio of the

two axes to one another, that is the length of *BC* divided by the length of *AC* or as the mathematicians would write it:

$$\tan \alpha = BC/AC = \textit{Gamma}.$$

The length of the lines *AC* and *BC* can be measured in any convenient unit, inches, centimetres, etc.

In our diagram the slope of the curve is 45 degrees, hence *BC* and *AC* are identical in length and so $BC/AC = 1$ which is the *Gamma*.

If now we take the other examples, our soft and hard films on the pages 25–26, and measure them in the same way, we shall find the soft gradation film has a *Gamma* of 0.6 and the hard film a *Gamma* of 1.5.

Now that we know how we can give a numerical value to the gradation of our sensitive material, we can get on with investigating the relation between gradation and development, a matter of the utmost practical importance. For this purpose we prepare a series of strips, all with the same series of step wedge exposures and then develop them in the same developer for varying times. When this has been done and the strips fixed, washed and dried, we shall see that the development has reached a definite maximum value. If we measure the densities and plot curves for the strips we find that *the steepness of gradation and also the Gamma value reach a definite maximum and then increase no more.*

That really gives us two maxima, namely maximum density, usually written *D max*, and maximum *Gamma*, written γ *max*, or more usually *Gamma infinity* or $\gamma \infty$. Both these values are really simple and easily understood, but when they appear in a book in their symbolised form they seem to frighten people. The two values *D max* and $\gamma \infty$ just mean *the density and the Gamma that can be attained by infinite development.*

Time-Gamma Curves

The results we have obtained with our developed strips can now be used in another valuable direction, namely in

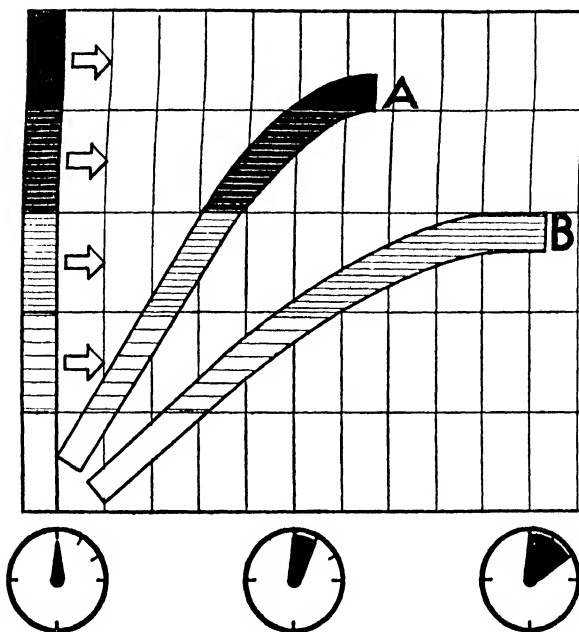
preparing a curve which shall clearly indicate the relation between the length of time of development and the growth of Gamma. In other words we can prepare a time-gamma curve. To do this we arrange a diagram in which time of development appears along the horizontal axis of our diagram, while on the vertical axis we have the Gamma values. As we can easily determine the Gamma from our blackening curves, so it is a simple matter to produce Gamma-time curves in turn.

On page 35 curves are given for two different developers and the differences between them are apparent at a glance. The developer of curve B causes a slow increment in Gamma and the maximum reached is only low; this is a weakly active and slow-working developer. With curve A the opposite is the case, not only is the maximum Gamma reached with a comparatively short development time, but it is a high figure at that. Here we have an energetic and hence quick-working developer.

From these two examples it will be clear that in Gamma time curves we have an excellent means of *characterising developers*, and of reading at a glance all the really important things we want to know about them such as their *relative energy* as developers, *the time required* to reach a particular gradation or gamma and, for any particular material, the *maximum gamma attainable*.

In practice, Gamma-time curves are not always available. Various *film manufacturers* supply such curves for their own material when developed with a *prescribed developer*. But the photographer who uses the various formulae given in this book may well ask himself what is the practical time of development for some particular film with a particular developer, not necessarily either the film or the particular developer recommended and supplied by any particular firm.

To answer this question with exactitude would require a Gamma-time curve for every developer and for every film or plate sold. This is obviously impossible in view of the tremendous variety of developers and materials available.



THE GAMMA TIME CURVE

The Gamma time curve shows how the contrast of a negative increases with the development time. In order to produce such a curve, the horizontal axis of the diagram shows development time, while the vertical axis shows the Gamma values. In the diagram the effect of two types of development is shown. The curves A and B have been produced by developers with very different properties. A is a rapid-working and contrasty developer. The curve rises steeply and reaches a high Gamma value in 6 minutes. B is a slow and soft-working developer. Hence the curve rises gradually and the Gamma value is much less than that in curve A. In this case 10 minutes was required to reach even this low Gamma.

Not only is it impossible, but it is also quite unnecessary.

It is very easy to exaggerate the importance, as well as the value, of the time-gamma curve in actual practice. On the one hand we know that with a normal developer a variation of half a minute either side of full development will not seriously affect gamma, and on the other hand we know that the range of modern papers, both *gaslight* and *bromide*, is so wide that we can obtain a good print from almost any negative whether it is hard or soft.

On these grounds it is obviously unnecessary to develop a negative so that it just exactly reaches a given gamma value, for example, 0.8. What we want is a negative that is developed to such a gamma value that it will produce a good print or enlargement. That is, it should fall between the limits of gamma 0.7 and 1.0. Once the practical value of this is realised the question of the right development time can soon be dealt with in the following simple manner.

Determination of Development Time in Practice

In *Table I* the best-known films on the market are arranged in three groups according to the development time which they require. The *middle group* (Group II) is that which requires *normal development time*, that is, the time given in the various formulae for each developer. The films in the other two groups (I and III) call for either a *shorter* or a *longer development time* as is indicated at the top of each group.

Example.—Suppose we have chosen the fine grain developer, No. 37, page 145. The average normal development time for this developer is 12 minutes. This will hold good for all films of Group II. If now we have a film of Group I, then the development time must be reduced to 2/3rds, that is to 8 minutes. If, on the other hand, we are dealing with a film belonging to Group III, we must increase the development time by one-half, that will be 18 minutes.

The normal development times given with the various

I.—FILMS, PLATES, AND DEVELOPMENT TIME.

GROUP A: 2/3 DEV. TIME

Anso Finopan RF
 Plenachrome RF
 Supreme 35 mm.
 Finopan 35 mm.
 F. G. Plenachrome 35 mm.
 Infra Red 35 mm.
 Isopan SF
 SS Panchromatic SF
 Superpan Portrait SF
 Commercial Pan SF
 Infra Red RF
 Portrait SF
 Barnet Ordinary
 Self Screen Ortho
 Special Rapid
 S.R. Pan
 Criterion Ordinary
 Iso Extra Rapid
 Defender Commercial
 XF Pan
 Portrait
 Fine Grain Pan
 XF Ortho
 Dupont Superior Pan I.
 Gevaert Panchromosa Microgran 35 mm.
 Panchromosa Special RF
 Ilford Auto Filter PI
 Commercial Ortho SF
 Auto Zenith PI
 F.P. 3 PI
 Fine Grain Ordinary SF
 Infra Red RF
 HP3 SF
 Press Ortho Serie 2 PI
 Selo FP 2 35mm.
 Selo Fine Grain Pan RF
 Selochrome PI
 Special Rapid Pan PI
 Special Rapid PI
 Selo Fine Grain Pan RF
 Kodak O. 250 PI
 B. 250 PI
 O. 120 PI
 Minox 10/10DIN
 Barnet F.G. Pan RF
 Press Ortho

Sensichrome RF
 Standard RF
 Criterion Enelite
 Extra Rapid
 Rapid Screenless Ortho
 Special Extra Rapid
 Defender HGS
 Pentagon
 Dupont Superior 2
 Superior 3
 Ensign Ortho RF
 Panchromatic RF
 Ultrachrome RF
 Fine Grain Pan RF
 Gevaert Panchromosa 35 mm.
 Express Superchrome 35 mm.
 Regular RF
 Panchromosa RF
 Ilford HP 3 PI
 Iso Zenith PI
 Hyperpanchromatic SF
 Portrait Pan SF
 Portrait Ortho Fast SF
 Selochrome SF
 Selo Ortho RF
 Selochrome RF
 Selo HP 3 Hypersensitive Pan RF
 Selo HP 3 35 mm.
 Soft Gradation Pan PI
 Selo HP 3 RF
 Zenith 700 PI
 Kodak P. 1200 PI
 P. 800 PI
 O. 800 PI
 P. 500 PI
 O. 500 PI
 Tri X Pan SF
 Ortho X SF
 Super XX SF
 Panatomic X SF
 Super Panchro Press SF
 Panatomic X 35 mm.
 Plus X 35 mm.
 Panatomic X RF
 Plus X RF
 Super XX RF
 Verichrome RF
 SS Pan RF
 Minox 17/10 DIN

GROUP B: NORMAL DEV. TIME

Anso Standard RF
 Superpan Supreme RF
 Superpan Press RF
 S. Plenachrome RF
 Ultra Speed Pan
 Superpan Press SF
 Super Pleno Press SF
 SS Plenachrome SF
 Commercial SF
 Commercial Ortho SF
 Triple S Pan SF
 SSS Ortho

GROUP C: 1 1/2 DEV. TIME

Barnet Prestopan
 Super Iso
 Portrait SF
 Soft Pan
 Super Pan
 Ultra Sensitive Pan
 XL Super Speed
 Ilford Golden Iso Zenith PI
 Kodak Super XX 35 mm.
 Dupont Infra Red

35 mm.—Miniature Film—PI Plate —RF Roll Film—SF Sheet (Cut) Film.

C

developer formulae are all chosen so that they will give a gamma of an average of 0.8 in that time, and if the above instructions relating to the three groups of films are followed then the average gamma of all negatives developed should not diverge notably from 0.8.

It is perfectly true that the rate of development may vary between films of the same group, it can vary between films of the same grade and maker, but the divergences from the general norm which can occur in this way should be quite easily dealt with by the choice of a suitable printing paper.

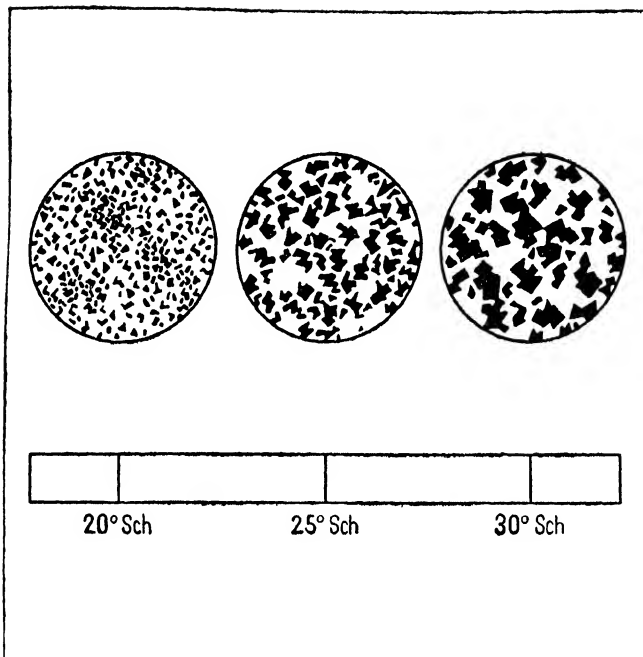
Grain and Graininess

Now that we have learned something of the way in which the blackening curve can throw light on development processes in general, let us follow the process of development somewhat more minutely, especially as it proceeds in the actual emulsion in film and affects the structure of the developed image.

If we examine an average negative with the naked eye it appears to consist of a homogeneous deposit of black silver with quite as regular a texture as a layer of black pigment. If, however, we use a fairly strong lens, we shall see that the silver deposit consists of numerous grains of quite varied and irregular form. (Page 39.) This irregular structure can intrude itself on our attention in somewhat unexpected and often unpleasant fashion if we proceed to make an enlargement from our negative. That is the outstanding result of graininess in negatives and is the reason why one of the most important problems in development technique, and especially the development of negatives, is the control of grain size and hence of graininess.

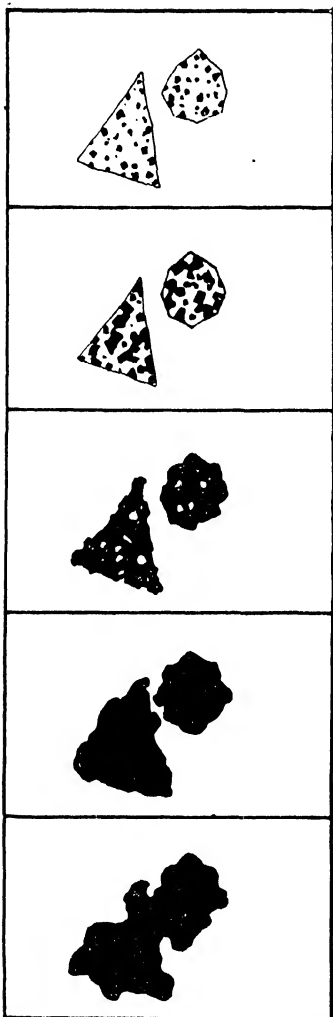
Grain and Development

Let us take a step further in our investigation of grain and graininess, and call to our aid a microscope giving us a much greater magnification. First let us glimpse at an undeveloped



GRAIN AND GRAININESS

If we examine an average negative with the naked eye it appears to consist of a homogeneous deposit of black silver, with quite as regular a texture as a layer of black pigment. If, however, we use a fairly strong lens, we shall see that the silver deposit consists of numerous grains of quite varied and irregular form. The more sensitive an emulsion is, the larger are its individual silver grains. A film of 30° Sch is enormously more grainy than one of 20°, while a film of 25° is midway between the two. This irregular structure can intrude itself on our attention in somewhat unexpected and often unpleasant fashion if we proceed to make an enlargement from our negative. That is the outstanding result of graininess in negatives and is the reason why one of the most important problems in development technique is the control of grain size and hence of graininess.



THE SILVER BROMIDE GRAIN

This diagrammatic representation of two emulsion grains at a very high magnification shows that development begins at definite centres on the grain (*Top*). These centres grow and soon the original form of the grain is altered by the appearance of reduced silver, which alters the outward form of the grain. As the development proceeds, it is seen that the reduced silver in the two adjacent grains bridges the gap between them and so forms one large, irregular grain of developed silver (*Bottom*). The effect of a fine-grain developer is to develop the single grains and to obviate the clumping together of adjacent grains.

emulsion. (Page 40.) We can see the individual grains of silver bromide and we note that they show crystalline form. What happens to these grains during development? Fortunately it is not necessary for us to carry through an extended investigation to answer this question. That has been done by many workers using photomicrography and cine-micrography and their results are at our disposal. From them we know that the actual process of development does not begin equally over the whole surface of one of the grains, rather does it start from some particular point on the grain. This occurs on many grains simultaneously and gradually each grain is reduced to black metallic silver: where two or more grains touch one another the whole mass tends to be reduced to a clump of silver whose form bears no resemblance to the original grains. Generally the *developed silver grains have a very irregular character and are much larger than the original grain of the emulsion.*

Page 40 illustrates various stages in the process of development; we see grains in which development has just begun, others in which it has advanced some distance and yet others where development is complete and the whole grain has been reduced to metallic silver.

Both the character and the size of the silver grains can be, and is, enormously influenced by the development process. For example, by developing for a short time, we can obtain a very fine-grained silver deposit, but only by sacrificing all that full development can give us, in particular the advantage of the full sensitivity of our material.

The graininess of negatives is naturally a function of the properties of the emulsion itself and the photographic manufacturer exercises all his ingenuity and care to ensure that his emulsions shall be as fine grained as possible. Nor do his efforts cease with the attainment of small single grain size, he equally takes every possible precaution against any clumping together of the grains in the emulsion.

The graininess which so often mars an enlargement is not due to the size of single grains, for these are far too small to

cause such an effect. It is caused by apparent clumping together of the grains. In a photographic film there may be up to 40 or 50 grains in various layers on top of one another. Developed photographic deposits thus appear irregular ; there seem to be large masses of grains, thus causing comparatively large masses of reduced silver in the negative. The mere touching of grains in the emulsion can help to this end, for, as we have seen in our study of the development process, a developable grain in contact with another which has received no exposure usually means that both are developed.

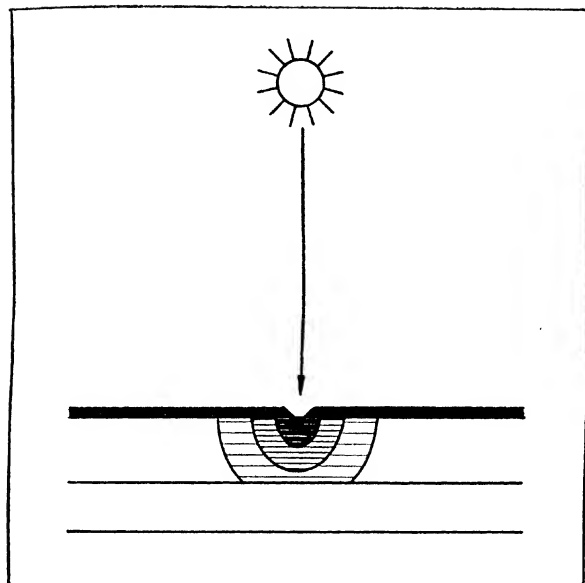
Scatter of Light in the Emulsion

Now that we have observed the process of development of a single grain of silver bromide and seen how the part affects the whole, we must give a little attention to another phenomenon which takes place in the emulsion, and investigate the way in which a beam of light acts and how it progresses as it passes into the photographic layer.

The photographic emulsion is what the physicist calls a *turbid medium*, and one of the notable properties of turbid media is their power of *scattering light*. Hence when a beam of light falls on a photographic emulsion it does not pass directly through it as would happen with a transparent medium, but it is scattered and so may reach areas which are not subjected to direct illumination.

This is illustrated on page 43, where we have a highly magnified section of a photographic emulsion and its support. The emulsion is protected by a shutter which allows a very fine ray of light to pass through a tiny aperture. This ray of light is scattered by the turbid medium, the emulsion, and so spreads laterally, thus affecting areas which are actually protected from direct light by the shutter.

It is quite easy to see that if the shutter had two tiny apertures close together, each allowing a tiny beam of light to fall on the emulsion, the lateral spread or scatter of the light in the emulsion would result not in two points each



IRRADIATION

The photographic emulsion is a turbid medium and therefore has the property of scattering light, a process which can seriously affect the sharpness of the image. The diagram shows a highly-magnified section of an emulsion which has been covered by a sheet of metal with a small aperture through which a beam of light falls on to the emulsion. With a very short exposure, only the point where the light meets the emulsion will be developed. But if the exposure is longer, the light is scattered so that it spreads beyond the area protected by the metal, and hence Irradiation takes place, although the area affected by the scattered light is actually protected by the metal cover.

affected by light, but in one diffuse area much larger in extent than either of the points due to the direct action of the light on the film. This property of scattering light is of real interest to the photographer because it controls that very important emulsion characteristic which we call *resolving power*, and is also the cause of the phenomenon known as *halation*, as will have been gathered from the above description.

Resolving Power

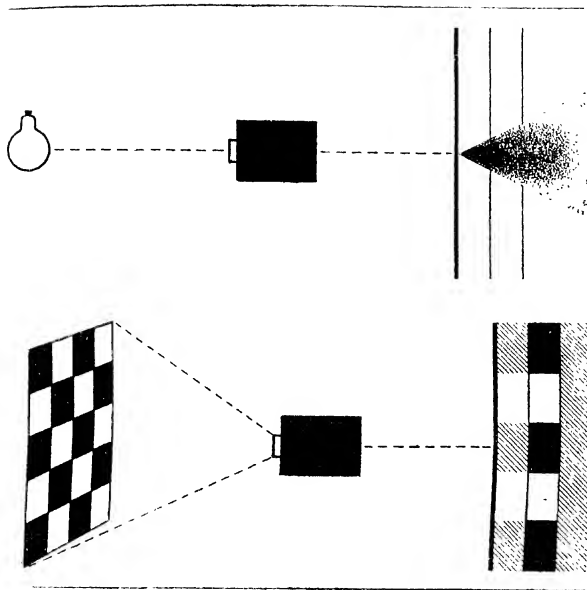
The resolving power of photographic material is almost wholly dependent upon the properties of the emulsion, and is hardly influenced at all by development. This follows naturally from the fact that each silver bromide grain which has been affected by light will be developed, whether the light fell upon it directly or reached it by scatter.

The less turbid an emulsion is, the better its resolving power, and the thinner the emulsion film the less scatter can occur. This fact has been taken advantage of in the production of modern films, and so we find a marked improvement in resolving power and an almost complete absence of halation in the so-called *single-coated* and the *thin film materials*.

The right choice of sensitive material is the most important factor in ensuring that the resolving power and suitability for enlarging shall be adequate and in making this choice it must be noted that we have a range of widely different materials to choose from.

Double-Coated Films

This film consists of a very *highly sensitive upper coating* which rests directly upon a much less sensitive emulsion. The object of these two emulsions is to confer the *greatest possible latitude in exposure* on the film. If, for example, exposure has been such that the upper sensitive emulsion is over-exposed, so that normally one would obtain a flat and



THE EMULSION THICKNESS

Top : A ray of light which enters the emulsion of the film is scattered inside, so that a sharply defined point is not formed in the negative. Instead, a halo is formed round the central black dot, which becomes less and less dense towards its edge. The "resolving power" of a film is thus greater when its emulsion is thin and transparent than when it is thick and translucent.

Bottom : Increasing the exposure latitude of a film by using a double-coated emulsion. The lower emulsion is less sensitive than the upper one, and if a flat image appears in the top one because it is given excessive exposure, the lower emulsion is affected and adds density where the single top emulsion would have lost it.

badly over-exposed negative, the *lower and less sensitive emulsion* ensures a usable and *printable negative*.

It has to be admitted that from the point of view of enlarging technique as practised to-day, the behaviour of the double-coated film is not as ideal as it might appear to be. This arises from the fact that the upper film will, as we know, scatter light, and as the whole of the light reaching the lower layer of emulsion must pass right through the upper, it is *unreasonable to expect it to produce an absolutely sharp image in the lower emulsion*. Where contact copies alone are required this is not a matter of great importance, nor is the effect very noticeable in low power enlargements, but where great enlargement is required, then the double-coated film fails badly. Hence the latitude of *double-coated films is of doubtful value, in particular for miniature work*. *Double-coated films should be used when the highest possible sensitivity is essential* and it is for this purpose which all the double-coated films are made.

Another point to be remembered affects development technique. *Fine grain developers are surface developers*, their action is predominantly at the surface of the negative, hence when these developers are used on double-coated film *the advantage of the double coat is lost* because only the upper or surface film is developed.

Thin-Coated Films

These films, which represent the most up-to-date emulsion making and coating technique, have a tremendous advantage from the point of view of *resolution of fine detail and in capacity for enlargement*. Moreover they enjoy a *latitude in exposure* which is fully large enough to cope with all the normal requirements of ordinary photographic practice.

From our earlier discussions we know that the thinner and more transparent our emulsion is the better for the sharpness of detail in our negative, for these factors are those which determine the extent to which the light incident on

the film will be scattered. The attainment of these advantages, in conjunction with a high degree of general and colour sensitivity, marks the single-coated thin emulsion film as a notable achievement.

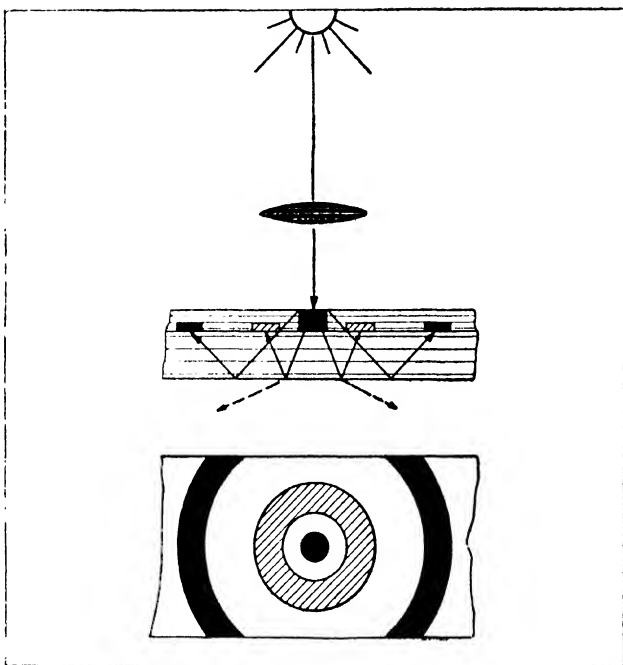
Halation

We have noted that resolving power is almost wholly a property of the emulsion and is not seriously affected by development; the case of halation is not quite the same.

If we follow the track of a beam of light through the emulsion and its support, we shall see (page 48) that if the light is not wholly stopped during its passage through the emulsion it travels on through the film base or glass, and if it meets the celluloid-air or glass-air inter-face at a particular angle, it is reflected back into the film or glass and can reach the emulsion again, thus producing halation.

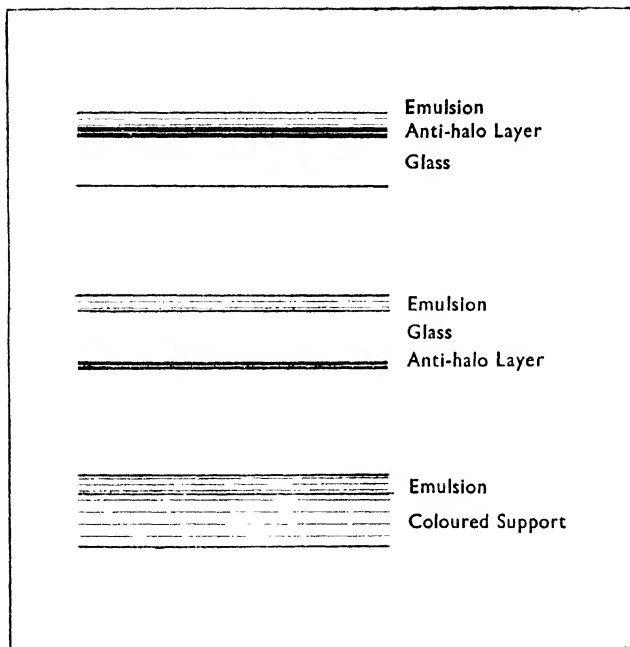
The method of reducing halation by preventing the reflection of light from the back of the film or glass, or better still, by preventing the light entering the film support or the glass, is shown on page 49. This method consists in using an *anti-halation coating or layer of colouring matter which absorbs light*, the layer being coated either on the back of the film carrying the emulsion, or between the emulsion and its support.

Such anti-halation cannot prevent scatter occurring in the actual emulsion layer when the subject being photographed displays glaring contrasts as in photographs taken against the light, or in those cases where a bright light-source occurs in the field of the picture such as street lamps, etc., in night-photography. Such effects as these can, however, be minimised by a judicious use of special development methods. Page 49 shows that it is possible by *confining the action of the developer to the surface of the film or plate to reduce materially the appearance of halation*. In order to understand such methods, we must know more about the progress of development.



THE ORIGIN OF HALATION

When a beam of light of sufficient strength falls on the emulsion, it not only passes through the emulsion but also through the glass or film support. When it reaches the glass-air or film-air boundary, it will be reflected back to a greater or lesser extent, depending on the angle at which it meets the boundary surface. In this way, it again reaches the emulsion on the under side and so produces a developable spot or halation. In the diagram, two forms of reflection are shown. In the case of the light falling at a steep angle, part of it is not reflected back and the part which is reflected is therefore of comparatively low intensity. The light which falls at a larger angle suffers almost complete reflection and hence the effect is much more marked. As the effect of halation is largely at the emulsion support surface, the use of a surface developer is one method of reducing the effect of halation.



PREVENTION OF HALATION

In the diagram, three methods are shown whereby halation can be prevented. *First*, by the introduction of an anti-halo layer between the emulsion and the glass. This method is used mainly with plates. *Secondly*, by the coating of the back of the glass or film with an anti-halo layer. This absorbs any light which passes through the emulsion of the glass or film and prevents it being reflected back. This method is used for plates, roll and cut film. *Third*, halation is prevented by coating the emulsion on a coloured support. This method is used largely with films for miniature cameras.

THE PROGRESS OF DEVELOPMENT

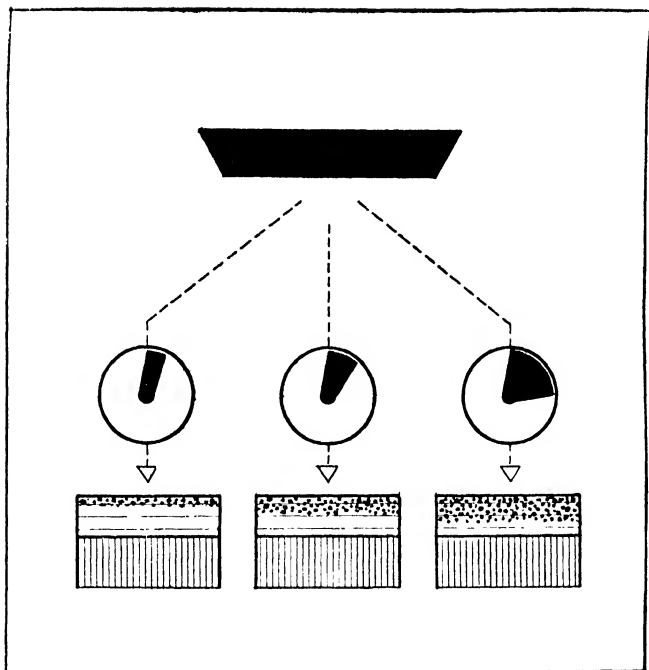
It might be expected that in the case of thinly-coated emulsions the process of development would take place through the whole film simultaneously; this is exceedingly rarely the case. Development almost invariably *commences at the surface exposed to the developer and only slowly progresses into the interior of the emulsion.* (Page 51.)

This is partly dependent upon the fact that the gelatine of the emulsion layer must swell in order to permit the developer to diffuse into it. Also as the developer acts on the silver bromide it naturally is used up or exhausted and development can only progress if the used-up developer is replaced by fresh solution.

The Depth of Development

The manner in which the developer will act and the speed with which it will penetrate the emulsion layer is largely dependent on the nature of the developer. Later on we shall discuss the differences between surface and depth developers in some detail.

One factor which plays an important part is the energy of the developer; an *energetic developer* produces a heavy density at the surface of a film before it has had time to penetrate to any depth, whereas a less energetic or *slow-working developer* will produce an equal density only when it has had time enough to penetrate into the emulsion and develop the deeper layers. This difference is shown diagrammatically on page 55. The density of both films will be the same to transmitted light, but the distribution of the developed grains will be different, those in the film developed with the weak developer being much more widely and deeply distributed than is the case in the film treated with the energetic developer.



PROGRESS OF DEVELOPMENT IN THE FILM

The clock faces show the passage of time during development and the sections show how the development process proceeds. We see that development begins at the surface of the film and progresses downwards into the thickness of the film. This method of progress is dependent upon various factors. First, the gelatine must swell to permit the diffusion of the developer. Next, as the developer is used up in development, it is essential that there should be a free flow or diffusion of the developer in order that action may take place in the deeper layers of the film. Hence while progress at the surface is rapid, later on more time is required for the developer to penetrate and act on the inner portion of the emulsion.

The Influence of Temperature

As is the case with most chemical reactions, and photographic development is a chemical reaction, the rate of development depends upon temperature. The higher the temperature of the developer the more rapid and energetic will be the progress of development. This rule holds good for all developer substances but the actual degree of acceleration for a given rise of temperature varies with the different developers.

The Increase in speed of development with an increase of 10° Centigrade is taken as the Temperature Coefficient of the developer. For example if we find that a particular developer works twice as quickly at 18°C. as it did at 8°C. then we say that it has a Temperature Coefficient of 2. The Temperature Coefficients of a number of the best known developers are given in the following table by J. M. Eder.

II.—TEMPERATURE COEFFICIENTS OF VARIOUS DEVELOPERS

Metol-soda	...	...	...	...	...	...	1.5
Metol-hydroquinone-soda	...	...	...	...	...	...	1.7—1.9
Hydroquinone-soda	...	...	...	...	...	...	2.2—2.6
Pyro-soda	...	...	...	...	...	...	2.2—2.4
Rodinal (para-aminophenol-caustic soda)	...	...	...	...	...	...	2.0
Glycin-potash	...	...	...	...	...	...	2.5—2.7
Pyrocatechin-potash	...	...	...	...	...	...	2.8

As may be deduced from this table the Temperature Coefficient is not solely influenced by the developer substance ; the formula, and in particular the quantity and type of alkali present, plays a part. The table is useful as giving a general idea of the effect of temperature on the several developers but should not be taken as more than a general guide from which useful deductions can be made. The smaller the Temperature Coefficient the less loss of energy suffered by the developer when cooled. For example we can see from the table that a metol-soda developer will be less affected at low temperatures than a hydroquinone-soda or a glycin-potash developer.

Development should, whenever possible, take place at about 18°C. (65°F.). Deviations from this normal development temperature will cause a shortening or lengthening of the time necessary for full development within certain limits and, in the case of most of the commonly used developers, tables are published showing the variation in time of development for the different temperatures.

From the details already mentioned it will be gathered that any generally applicable table of times is hardly possible; the table given below as an example is applicable for fine-grain developers of the metol-borax type (p. 144).

III.—TIME-TEMPERATURE TABLE FOR METOL-BORAX DEVELOPER

°C.	°F.	Development time in minutes		
14	58	...	...	22
16	61	...	...	16
18	64-65	...	...	12
20	68	...	...	10
22	72	...	...	8
24	75	...	...	6
26	79	...	...	4

Here the normal development time is 12 minutes ; if the temperature is 16°C. then 16 minutes is required, whereas if the temperature rises to 22°C. then only 8 minutes is required for full development. It would be quite wrong to conclude from this table that a high temperature was an unmixed advantage. Do not forget that over-warm developer may cause unpleasant results such as softening or even melting of the emulsion film, fog and other troubles (p. 278).

When is the Developer Exhausted ?

This very practical question is difficult to answer by any simple and generally applicable formula, because the useful life of any developer depends upon a whole series of factors not easily assessable.

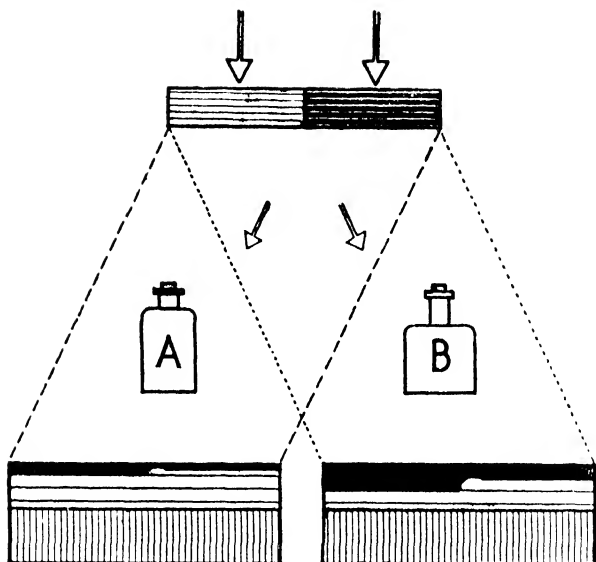
Of these the most important is the quantity of negative

material which a given volume of developer solution will develop. It is also important to consider whether all the developing will be done in one big operation or, on the other hand, if intervals of time will occur between one batch of developing and another. The class of material developed will also play a part, the thickness and the type of emulsion, its content of stabilising constituents and the extent to which they will retard the development process. Another factor is the amount of surface of the developer exposed to the influence of atmospheric oxidation and the time of such exposure. Finally it must not be overlooked that it is not the total area of film that is to be thought of as contributing to the exhaustion of the developer but only that part which has actually undergone development.

For all these various reasons any direct or comprehensive answer to our question is not easy. For the majority of developers in use to-day, details will be found in the directions for use which will indicate the quantity of material developable by unit quantity of developer and will also usually say what extra time of development should be allowed after a certain number of films have been developed. In some cases the necessary replenisher is given and this is a matter that should receive the attention of all careful and economical workers (p. 127).

Development Effects

Page 55 illustrates an interesting development effect which often causes some bewilderment and misunderstanding. It will be seen that the left half has had a strong exposure while the right half has only received a weak one, hence the blackening on the right side is thin compared to the left. We notice, however, that the margin or boundary of the heavy black deposit appears thin or weak, as if there were but few developed grains there. In fact, the heavy deposit appears to have a light halo around it. This appearance, which can often be found more or less in negatives where



RAPID AND A SLOW DEVELOPMENT.

The diagram shows one plate, which has been given on one half a long, and on the other half a short, exposure. In the case shown on the *left* the negative has had a rapid development, that on the *right* a slow development. But in both cases equal blackening has resulted. The energetic developer A has caused a strong blackening on the surface of the film, while the slower developer has attained a like blackening, but has required much more time and the developer A gives a strong surface image, while developer B has given rise to an image which is much deeper in the film, although both pictures appear to have the same density when examined by transmitted light.

It will be noted that on each negative there is a lack of density at the boundary line between the heavy and the lighter exposure. This has the appearance of a light band and is due to the effect of the large amount of bromide set free in the developing of the heavy density.

notable contrasts appear, is due to the fact that during the development of the deposit, comparatively large quantities of bromide were set free (see page 19), which had the effect of retarding the development of the neighbouring area. Hence *the heavy deposit is surrounded by an area which received less development than the rest and so appears lighter*. Bromide set free in this manner during development can give rise to a number of troubles of a similar nature as we shall see in a later chapter.

Another effect may be mentioned here which has a similar origin. When a negative has a large evenly-exposed area in it, it sometimes happens that *the centre of the area appears lighter than the surrounding part* instead of all having an equal density. This is due to local concentration of the liberated bromide in the centre of the area with consequent retardation of the development process, whereas the outer areas received fresh developer from their boundaries.

The obvious precaution to take in obviating all these troubles is to ensure that *the developer is kept in movement* during the whole process of development, so that fresh developer is constantly being mixed with that which is used up in the process of development.

The Influence of Agitation

The development effects described in the preceding section indicate the influence which the agitation of the developer can have on the progress of the actual process of development. Let us consider first an extreme case in which the solution is completely undisturbed and suffers no agitation whatever. In such a case the areas close to high lights will be occupied by increasing quantities of exhausted and bromide-rich developer and as a result the development will be slowed down.

In the shadow areas of the negative the developer will naturally be only slightly affected because only small amounts of silver bromide have to be reduced; therefore development

will proceed unaffected. This means that in the high lights the development is restrained and so the contrast of the negative is diminished. In addition to this markings of varying density may be developed which, as we shall see later, (p. 110) can produce serious faults.

Next let us consider a case in which the negative or the developer solution has hardly been stirred, certainly not sufficiently to move the exhausted developer away from the surface of the negative quickly. That means that the major part of the developing has to be done by this exhausted developer and that entails a greater or lesser degree of retardation of the development. This emphasises the fact that the agitation of the developer is no matter of insignificant influence on the speed of the development but is of particular importance as regards the time of development and the contrast of the negative.

Hence we should ensure by good agitation of the developer that the exhausted solution be replaced by fresh developer as quickly as possible and that throughout the process the developer be maintained in a well-mixed condition. This does not necessarily mean constant agitation although steady movement is advisable. It may be taken that as an example of the effect of agitation on the progress of development that where intermittent agitation is used about 50% longer development time should be given than would be considered necessary with constant movement.

THE COMPOSITION OF THE DEVELOPER

A developer consists of a number of different chemicals :

- (1) *The developer substance,*
- (2) *The preservative,*
- (3) *The alkali,*
- (4) *An agent which restricts fog formation or slows the action of the developer as a whole.*

The nature of the chemicals, as well as the relative quantities present, govern the properties of the developer to so great an extent that it is important to understand exactly the role of each constituent.

While it is quite correct to say that the most important constituent of any developer is the developer itself, it does not appear correct to commence a description of a developer with the actual developing agent for the simple reason that it is the composition of the solution that plays the dominant part in determining the photographic properties of the developer. We know, for example, that many developing agents can provide slow acting and weak, or rapid and contrasty, developers according to the composition of the solution and the relative amounts of preservative and alkali present. The photographic behaviour of the developing agent is therefore less a function of the substance itself than of the total composition of the developing solution. Hence it appears logical to deal first with the other constituents and to explain their effect on the developer substance when they act in combination with them.

The Preservative

Development, as we have already seen (page 18) is a reduction process, in which silver bromide is reduced to

silver and the developer substance itself undergoes a change, being oxidised. It has to be noted, however, that the development process itself is not necessary for the oxidation of the developer. Mere exposure to the oxygen of the atmosphere will quickly oxidise the developer and render it useless. *To prevent this oxidation taking place*, or at least to reduce its rate, a preservative is added to the developer and the most widely used substance for this purpose is sodium sulphite.

SODIUM SULPHITE

It can be got in two forms, as a crystallised salt and as an anhydrous powder. The crystalline form is more commonly used in England, but the anhydrous salt is preferred on the European Continent and in the United States. *One part by weight of the anhydrous salt is the equivalent of two parts by weight of the crystalline.* In all other respects the two salts are similar in their action.

The anhydrous salt is often preferred because of its better keeping qualities; the crystallised salt tends to change in the air and the decomposition gives rise to sodium sulphate which does not act as a preservative to developers. Another advantage of the anhydrous salt is that it dissolves quickly and easily.

Generally speaking the purity of the anhydrous sodium sulphite on the market leaves nothing to be desired. This is of particular importance in compounding fine-grain developers which often contain a high proportion of sulphite and in which the sulphite plays quite an important role other than that of preservative.

As, however, the principal object of adding sulphite to a developer is to guard against the oxidation of the developer substance by the oxygen of the air, it is naturally important to adopt a definite sequence of operations in compounding a developer and in general *the order of addition* of the components to the solution should be

1. Developer substance.
2. Sulphite.
3. Alkali.

This order should not be varied unless special instructions are given with any formula for some other order to be followed.

BISULPHITES

It is sometimes advantageous to replace sulphite by bisulphite, and the salt most generally used for this purpose is either *potassium* or *sodium metabisulphite*.

There is an important difference between sulphites and bisulphites in that *solutions of sulphites are weakly alkaline, whereas solutions of bisulphites are distinctly acid*. This difference materially affects the properties as well as the applications of the two salts.

Developing agents or substances, with certain special exceptions, are only active in alkaline solution, hence when bisulphites are used there must be sufficient alkali present in any normal developer to neutralise the free acid and convert the bisulphite into sulphite. In practically all published formulae it will be seen that the proportion of alkali present is ample for this purpose, the only exceptions to this rule being special developers such as *Amidol* and certain of the fine grain and physical developers which will be discussed later in this book (page 153).

Potassium metabisulphite is sometimes objected to on account of expense and sodium bisulphite suggested as a substitute. The sodium bisulphite of commerce is mainly sodium metabisulphite and not the sodium hydrogen sulphite which comprises true sodium bisulphite. This is no disadvantage to the photographer and he can at all times replace *potassium metabisulphite* by an equal weight of the *sodium salt*, as the properties of the two materials are practically identical.

Another form in which bisulphite is sometimes recommended, especially in Europe, is *bisulphite lye*, which consists of a concentrated solution of sodium bisulphite containing about 10 oz. of solid bisulphite in 32 oz. of solution. (It has a specific gravity of 1.32 at 60°F. and is designated as

35° Baume.) It is but little used by photographers either in Britain or the United States. *One hundred parts by weight of potassium metabisulphite are equal to 205 parts by volume of bisulphite lye, i.e., 10 oz. by weight metabisulphite = 20½ fluid oz. of lye.*

The amounts of the alkalies commonly used in photography which are necessary to neutralise unit quantities of potassium metabisulphite are given in the following table by L. P. Clerc.

IV.—EQUIVALENT QUANTITIES OF ALKALIES

<i>To neutralise 100 parts by weight of potassium metabisulphite take</i>	Of sodium carbonate anhydrous	95 parts
	„ sodium carbonate crystal ...	258 „
	„ potassium carbonate dry ...	124 „
	„ sodium hydroxide (caustic soda) ...	36 „
	„ potassium hydroxide (caustic potash) ...	50½ „

SULPHITE OR BISULPHITE ?

We have seen that the addition of alkali to a bisulphite converts it into a sulphite and the question may be asked why, then, should we use a bisulphite in preference to sulphite, and what advantage do we gain ?

In the first case, as we shall see in a later chapter, it is a common custom to make up developers in *two solutions*, one of which contains the developing substance and the sulphite and the other the alkali. In such a case *bisulphite should always replace sulphite* because of the much better keeping properties it will confer on the solution by reason of its acid reaction inhibiting oxidation.

Next there is a decided advantage in using bisulphite when it becomes necessary to prepare *more than usually concentrated solutions of developer*, and here the greater

solubility of potassium salts as compared to sodium salts is an advantage.

Another point which must not be overlooked is that in the case of a one-solution developer in which sodium sulphite and bisulphite occur with sodium carbonate, the *sodium bisulphite neutralises an equivalent amount of sodium carbonate* in accordance with the following reaction: *Sodium bisulphite + sodium carbonate = sodium sulphite + sodium bicarbonate*. In this way the proportion of alkali is reduced, an apparent restraining action is exerted and the life of the developer is prolonged because some of the alkali has been destroyed. It is also found that such developers give somewhat less fog and that the bicarbonate formed acts not only as an anti-fogging agent, but also as a buffer to prevent rapid oxidation of the developer.

In addition to its action as a preservative, sulphite has another valuable property which is made use of in development processes. It is *a solvent for silver bromide and for metallic silver* when they are in finely divided condition and so is made use of in certain fine-grain developers which act in part as chemical but also in part as physical developers, as will be seen when we come to discuss these processes.

The Alkali

Solutions of developer containing only sulphite have, as a rule, only very weak developing powers, and may, indeed, show none at all. *In order to develop their full action, the addition of alkali is necessary.*

The alkalies most widely used in photography are sodium carbonate, potassium carbonate and the caustic alkalies sodium and potassium hydroxide. The quantity and the character of the alkalies exert a profound influence on the properties of developers. There is a notable difference between the action of the carbonated alkalies, that is, sodium and potassium carbonates, and the caustic alkalies, the latter

giving developers of much greater energy than the carbonates.

CARBONATE OF SODA

This is the most widely used of all the alkalies, and appears on the market in three forms.

Crystal sodium carbonate, the most commonly used form in Britain, contains ten molecules of water and so is called deca-hydrated and has 37 per cent by weight of anhydrous sodium carbonate. This is the form that is always spoken of as crystal sodium carbonate.

Next there is *anhydrous sodium carbonate* which theoretically is free from water and contains nominally about 98 per cent pure sodium carbonate. This is spoken of either as anhydrous or desiccated carbonate.

The third form contains one molecule of water and is termed *mono-hydrated sodium carbonate*, and contains 85 per cent by weight of anhydrous carbonate. The equivalent weight relation which these three varieties bear to one another is shown in the following table.

V.—EQUIVALENT QUANTITIES OF CRYSTALLINE AND ANHYDROUS SALTS

100 parts by weight of crystal sodium carbonate	=	37½ parts by weight of anhydrous
" " " " " " "	=	85½ parts by weight of monohydrate
100 parts by weight of anhydrous sodium carbonate	=	270 parts by weight of crystal salt
" " " " " " "	=	120 parts by weight of monohydrate

These equivalents are not exact, but are quite near enough for all practical purposes.

CARBONATE OF POTASH

It occurs only in one form, the anhydrous salt, but it is a very hygroscopic material, that is, it has a strong attraction for water and absorbs it rapidly from a moist atmosphere. Hence it should never be kept in paper packets but always in bottles, having either a close-fitting glass stopper or better still a well-waxed and sound cork.

In general there is nothing to be gained by substituting potassium carbonate for sodium carbonate in developer solutions; it can be used in practically the same proportions, or more exactly *13 parts by weight of the potassium carbonate are equal to 10 parts by weight of sodium carbonate*. Where it has an advantage is in the preparation of concentrated developers, as its solubility is much greater than that of sodium carbonate.

CAUSTIC ALKALIES

These are much more energetic in their action than the carbonated alkalies, and are only used in those cases where *a powerful and quick-acting developer is required*. As might be expected, developers compounded with caustic alkali have poor keeping properties and are soon exhausted. The reason for this difference in properties between developers compounded with carbonated and those made with caustic alkalies is of sufficient interest to call for a little special explanation.

When sodium carbonate is dissolved in water, part of it is split up, or as the chemist calls it, hydrolysed. As a result, caustic soda and bicarbonate of soda are formed although only in small quantities at any one moment. When development is taking place the caustic soda or sodium hydroxide is used up and as that happens more carbonate hydrolyses. Hence the carbonate acts as a sort of reservoir of caustic alkali. If we had caustic soda in place of the carbonate to give the same alkalinity, it would soon be used up and the activity of the developer would cease. Obviously the use of sodium carbonate allows us to use a small concentration of alkali

and get the utmost work out of it. The above explanation also shows why it is rarely possible to substitute caustic alkalies for carbonates in normal developers.

As their name implies, caustic alkalies possess corrosive properties, a fact which must be remembered when handling them. They can *burn the skin, are very dangerous to the eyes and act vigorously on other materials* of both organic and inorganic origin. They are also intensely hygroscopic and so *must be preserved from contact with moist air* if they are to be kept in solid form. They are usually sold in sticks which are kept in bottles with well-fitting waxed corks, or in powder form in tins with close-fitting lids.

There is no difference between the potassium and sodium hydroxides so far as photographic uses are concerned, other than that *10 parts by weight of the sodium salt are the equivalent of 14 parts by weight of the potassium.*

Among other energetic alkalies mention may be made of *sodium metasilicate* (Metso). This substance, as the table on p. 67 shows, is almost as alkaline as the hydroxides and equal to the carbonate. It has the advantage that it does not attack gelatine and also that it tends to reduce any excessive swelling. As a result it helps toward the quick drying of films developed in formulae containing it.

SUBSTITUTION OF ALKALIES

We have already given the proportions in which one alkali can be substituted for another, but it will be realised that such substitution is only possible between members of the same group. For example, one can substitute one carbonate for another, or one caustic alkali for another, but it is not possible to substitute the alkali of one group for another.

Of late years another form of substitution has come into use, and in some formulae one finds *Formalin or paraformaldehyde* substituted for caustic alkali. Formaline is a solution and paraformaldehyde is a white powder which produces formalin when dissolved in water. One of the most

useful properties of formalin is its *hardening effect on gelatine*, and it is widely used for hardening the emulsion film of photographic materials. It can exercise this property when added to a developer, but it also has another action, namely that it reacts with sodium sulphite and sodium hydroxide is one of the products of that reaction, thus :

Formalin + sodium sulphite + water = Formo-sulphite + sodium hydroxide. Hence the result of adding formalin to a developer containing sulphite but no alkali is *equivalent to adding caustic soda to the developer.* In addition we have the hardening action on our emulsion film and there is also a somewhat unpleasant and irritating smell.

MILD ALKALIES

For some years now another group of alkalies have found application in photographic practice to which the name "mild alkalies" might be given. Of these the most widely used is *borax*, or *sodium tetraborate*, which finds its widest use in the compounding of fine-grain developers.

Another compound which falls in this group is *Kodalk* introduced by Kodak, which is more alkaline than borax, somewhat more easily soluble, but less alkaline than carbonate. When used as substitute for carbonate, *two parts by weight of Kodalk are the equivalent of one part by weight of carbonate* in normal developers. As Kodalk contains no free carbonate there is no danger of bubbles of carbonic acid gas being formed when an acid stop-bath is used, a very real advantage in certain circumstances. (For formulae containing Kodalk, see page 165.)

In the chapter on fine-grain developers certain other mild alkalies will be discussed as well as organic substances such as *Triethanolamine*, *Acetone*, etc. The properties of *tribasic sodium phosphate*, the action of which lies between that of carbonate and caustic alkalies, will also be dealt with.

ALKALIES AND pH VALUES

So far in this book we have spoken of alkalies as caustic, energetic or mild, a description which from a scientific

standpoint leaves much to be desired. The alkalinity or acidity of any solution can be exactly measured and equally exactly described in terms of its pH value. A full understanding of exactly what is meant by pH value is not necessary for the photographer, it can be studied in any advanced text-book of chemistry. For our purpose it is sufficient to know that pure water, which is neither acid nor alkaline but neutral, has a pH value of 7, that any pH below 7 indicates acid or above 7 indicates alkaline and that the higher the pH value the more alkaline the solution is as:

VI.—pH-VALUES

pH-value	Solution is:					
0—2	strongly acid
3—4	acid
5—6	weakly acid
7	neutral (pure water)
8—9	weakly alkaline
10—11	alkaline
12—14	strongly alkaline

In the following table taken from *E. T. Howell, D. R. White* and *J. R. Weber* the pH values are given for a series of alkalies, preservatives and mixtures of these developer constituents.

VII.—pH-VALUE OF ALKALIES, PRESERVATIVES AND MIXTURES

Sodium or potassium hydroxide	...	...	...	...	...	13.0
Trisodium phosphate	...	...	...	...	...	12.0
Sodium carbonate	...	...	...	...	...	11.6
Sodium metasilicate (Metso) 0.1%	...	...	...	...	...	11.5
Triethanolamine	...	...	...	...	...	10.6
Trisodium phosphate 0.2%	...	...	...	...	...	10.6
Sodium carbonate 0.1%	...	...	...	...	...	10.0
Kodalk 0.2%	...	...	...	...	...	9.9
Potass : sulphite 10% + Trisodium phosphate 0.2%	...	...	...	...	...	9.9
Potass : sulphite 10% + Kodalk 0.2%	...	...	...	...	...	9.9
Potass : sulphite 10% + Borax 0.2%	...	...	...	...	...	9.8
Sodium sulphite 10%	...	...	...	...	...	9.7
Borax 0.1%	...	...	...	...	...	9.5
Sodium sulphite 10% + Borax 0.2%	...	...	...	...	...	9.5
Potass : sulphite 10%	...	...	...	...	...	9.4
Sodium sulphite 10% + Borax 0.2% + Boric Acid 1.4%	...	...	...	...	...	8.1
Boric acid	...	...	...	...	...	6.3

Where the percentage strength of solutions is not given the value relates to saturated solutions.

Although in the table the differences between the pH values of the various solutions appears small remember that the pH figures are logarithm values and so a solution of pH 10 is ten times more alkaline than a solution having a pH value of 9. This latter in turn is ten times as alkaline as a solution with a pH value of 8 and so on, thus a small change in pH indicates a notable variation in alkalinity. A further understanding of the significance of pH values can be gained from the following table of pH values of various developers taken from measurements made by E. T. Howell and E. Lowe.

VIII.—pH-VALUES OF VARIOUS DEVELOPERS

Rodinal	...	...	...	...	...	...	pH=12.3
Edwal 102	...	...	...	...	...	...	10.7
Metol-hydroquinone-sodium carbonate	...	...	...	...	...	...	9—10
Kodak D.76	...	...	...	...	...	...	8.6
Buffered borax	...	...	...	...	...	...	7.9
Kodak DK 20	...	...	...	...	...	...	8.15
Sease No. 3	...	...	...	...	...	...	7.8
X33	...	...	...	...	...	...	7.8
Edwal 12	...	...	...	...	...	...	7.5
Amidol-sulphite	...	...	...	...	...	...	7.0

As the table shows the pH values of developers cover a very wide range from strongly alkaline through weaker and very weak alkaline to neutral.

The table also allows us to draw a conclusion of particular value in connection with fine-grain developers. As we shall see later (p. 143) solutions of low alkalinity are important for fine-grain developers. In the preparation of such solutions two possibilities offer themselves. Either we can use a strong alkali in weak concentration or a mild alkali in higher concentration, for example we can take a 0.1% solution of sodium carbonate or even weaker, or a 0.2% or stronger solution of borax. Which will give us the best result?

The answer is that we shall obtain a more constant work-

ing and a better keeping developer by using a mild alkali at relatively high concentration than if we use a weak solution of a strong alkali. Similar considerations enter into the use of the so-called "Buffer-mixtures" in developers. Perhaps the best known example is the Buffered Borax Developer No. 42 (p. 146). This formula contains a relatively large quantity of borax as alkali and in addition a quantity of acid, namely boric acid. This has the effect of stabilising the pH value and acting as a buffer against any violent change, hence its name. Such developers are characterised by their constant or even working properties as well as good working life.

Restrainers

The great majority of developers fulfil, more or less completely, the important function of acting only on the exposed silver bromide in sensitive materials and leave unattacked that portion of the emulsion which has not received any exposure. Their action is selective and does not lead to a general fogging of the whole of the sensitive surface.

In order to ensure that they shall *produce an image completely free from fog*, a restrainer is made use of and the substance most widely used for this purpose is potassium bromide.

POTASSIUM BROMIDE

acts not only as a fog preventer but also as a restrainer, that is, it *slows down the rate of development*. This action varies with different developers. In many cases the restraining action is very strong, in others the effect is only small, and it is important to remember this difference and take it into account when compounding developers for special or even general purposes.

In the following table there are set out examples of the percentage lengthening of development time caused by the addition of an equal quantity of potassium bromide.

IX.—LENGTHENING OF DEVELOPMENT BY THE ADDITION OF POTASSIUM BROMIDE

Developer	Percentage lengthening of development time			
Glycin-potassium carbonate	300%
Glycin-caustic soda	200%
Hydroquinone-caustic soda	400%
Para-aminophenol-potassium carbonate	17%
Amldol	150%
Hydroquinone-potassium carbonate	140%
Para-aminophenol-caustic potash	100%
Pyrogallol-potassium carbonate	80%
Metol-potassium carbonate	25%

It will be seen that a metol-carbonate developer is relatively insensitive to the action of potassium bromide, whereas a hydroquinone-caustic developer is strongly affected and the development time notably prolonged. This emphasises the important fact that the effect of potassium bromide as a restrainer depends almost wholly on the composition of the developer. It should also be remembered that the addition of potassium bromide usually results in a *reduction of the contrast* in the developed image.

SUBSTITUTION OF BROMIDE

The substitution of the *sodium salt* for potassium bromide is not recommended, commercial sodium bromide being usually less stable than the potassium salt.

The use of *ammonium bromide* is definitely dangerous because the presence of free alkali in the developer sets free ammonia which is very likely to cause a so-called *dichroic fog* (see page 280), a very undesirable effect.

Some formulae contain *potassium iodide* which also acts as a restrainer and an anti-fogging agent, but the quantity should always be very small, very much less relatively than is permissible with potassium bromide. Potassium iodide in appreciable quantities is a disadvantage because it produces silver iodide in the sensitive material which is somewhat

insoluble in fixing salts and so *lengthens unduly the fixing time*. On the whole the use of potassium iodide as a restrainer is not recommended for the above reasons.

Certain organic compounds, notably *nitrobenzimidazol* and *benzotriazol*, have the interesting properties of acting as anti-fogging agents without affecting in any way other properties of the developer. They are used in very small quantities, one part in ten thousand of the developer being a perfectly satisfactory proportion to use.

The use of compounds of this type is sound practice in every-day work, as they afford real protection against any *tendency to fogging* by the developer itself, or by *variations in its preparation, too high temperature* or even *prolonged development*. They also have an excellent effect when somewhat stale or *badly stored sensitive material* have to be used. Up to the present they have not enjoyed any wide application, and as they are somewhat complex organic compounds their price has naturally been high. With a much wider appreciation of their valuable properties they are likely to find a place in every modern developer. They are now being produced under the name of *Developer Improvers*.

Commercial Developer Improvers.

Johnson's One-Four-Two, Three-Two-Six, P.A.C. Latitol U, B and WT. Kodak Anti-Fog Powder.

Other Additions to Developers

When *hard water* is used for the compounding of developers a milkiness or turbidity is often produced; this is caused by the action of *alkali carbonate* on the lime salts present in the water. If the amount of lime salt is excessive a troublesome precipitate of carbonate of lime may be deposited on the sensitive film unless the developer has been filtered or the precipitate destroyed in some other manner. The formation of this precipitate of carbonate of lime can be prevented by the addition of certain phosphates.

Sodium metaphosphate is used for this purpose in the form of a 10 per cent solution in water, and in the proportion of

3 to 5 parts per thousand. As the solution must be *added to the water before the developer is compounded* and not to the made-up developer, the simplest procedure is to treat a gallon of the water with about three-quarters of a fluid ounce of the sodium metaphosphate solution and then use the water for making up the required developer.

Calgon is a proprietary compound put on the market for the same purpose; It is essentially *sodium hexameta-phosphate* and can be added to the developer solution. In general, one part per thousand is sufficient for all except very hard waters. Where the amount of lime present is high the proportion of *Calgon* can be slightly increased.

Wetting Agents

Wetting agents are used in many branches of industry with most useful results and in recent times have found successful application for photographic purposes, particularly as additions to developers.

In order to understand the action of a "wetting" agent we must know what the operation of wetting really is. It may be defined as the forming of a continuous adsorbed film of liquid upon the surface of any desired solid or on that of another liquid. The capacity of a liquid for wetting depends to a large extent upon its surface properties.

The surface or interface of a liquid where, for example, it is in contact with air, behaves differently from the liquid layers lying beneath it. If a needle be stroked by the fingers sufficient grease will remain or be transferred to the needle to repel water and allow it to float so long as it is laid down carefully lengthwise on water. If, however, one end be pressed so that it penetrates the water the needle instantly sinks. Thus the surface of the water behaves as though it were a thin membrane and resisted rupture. There is, in fact, a force, which is called surface tension, acting along the surface of the water which tends to prevent the surface

being broken. This surface tension is also the force which tends to prevent liquids from spreading evenly over a surface and so wetting it completely and evenly. Wetting agents are substances which have the power of lessening this surface tension and so facilitating the spreading or wetting of a liquid or another surface.

A simple experiment will demonstrate this. If we take a vessel full of water and plunge a piece of old film into it, quickly withdrawing the film we shall see that the whole of the surface of the film is by no means wetted, that on the contrary the moistening has only been in patches here and there. If now we repeat the experiment with the difference that we add a wetting agent to the water, usually one part per thousand is ample, we at once observe a very notable difference for the whole surface of the film is now covered by a complete even film of water.

Of what benefit will this wetting effect be in photographic practice ?

The first and obvious advantage is in the assurance of a quick and even wetting of film or plate in the developer and the safeguarding in this way against air bubbles or bells and other inequalities of wetting. This is of quite special importance when using daylight developing tanks (p. 103) in which the spiral leads for the film leave but little space for contact between film and developer. Quick and even wetting of the film is equally of importance when high speed development is in question as described on p. 168.

Commercial Wetting Agents

P.A.C. Wettol, Kodak Wetting Agent, Aerosol, Easy-Wet, Spray-brite, Foto-foam and P.A.C. Tankronol. (This last is a developer which incorporates a wetting agent as well as other novel features.)

Developing Agents

We have already learned that developing agents or substances are reducers (see page 18), but that not every reducing agent can act as a photographic developer. For a reducing agent to act as a developer it must possess the

property of reducing only the exposed silver bromide and of leaving the unexposed material unaltered.

Fortunately there are a large number of compounds available which possess this quality although they differ notably in both chemical and photographic properties, and their action is to a very large degree dependent on the composition of the developer in which they play the part of reducing agent.

In judging the properties of developing agents the following points are all of importance and due consideration must be given to them.

- (1) *Solubility.*
- (2) *Fogging effect and/or discoloration of film or fingers.*
- (3) *Reaction to changes of temperature.*
- (4) *Reaction to bromide addition.*
- (5) *Behaviour with carbonate and caustic alkalies.*
- (6) *Keeping properties and rate of exhaustion.*
- (7) *Influence on graininess.*

METOL

(Elon, Pictol, Rhodol, Genol.) *Methyl-paraminophenol sulphate*

Metol is easily soluble in water and permits of the preparation of concentrated stock solutions. If these are beyond a certain concentration there may occur a precipitation of the metol base by the *alkali sulphite*. This can be remedied either by ensuring that the whole of the metol is dissolved before any further addition is made or by the addition of *alcohol* in the proportion of *one-tenth by volume* to the solution. *Acetone* can also be used in even smaller proportion, namely *25 parts per 1,000*.

Metol responds well to the addition of *bromide*, giving a very clean working developer without any staining of either film or fingers. The energy of the developer is only slightly affected by low temperature, and is also but slightly reduced by the addition of bromide. Metol alone with either *sodium*

or *potasslum carbonates* gives a rapid working developer when the alkalis are in high concentration, but the speed of development can easily be controlled by dilution. The use of *caustic alkali* with metol is not recommended as there is a tendency to excessive fog.

When used with *sulphite* alone without *alkali*, metol provides a slow-working, fine-grain developer, but it is preferable to use a *mild alkali* such as *borax*, which accelerates the rate of development without increasing the grain-size of the image appreciably.

Developers containing metol as the sole developing agent are not very widely used, but metol in combination with *hydroquinone* provides the most widely used developer in photographic practice.

All metol developers keep well and are only slowly exhausted.

Metol had the reputation of causing poisoning for a number of years; this poisoning, which took the form of a painful *dermatitis*, was traced to certain impurities in metol and not to the metol itself. To-day good quality metol is free from such impurities, but unfortunately some people are peculiarly sensitive to it and still suffer attacks from time to time (see page 274).

HYDROQUINONE

Quinol, Para-dihydroxybenzene

Hydroquinone is fairly soluble in cold, easily soluble in warm water. In general it is a clean-working and non-staining developer.

In some respects its properties are in marked contrast to those of *metol*, it is notably affected by low temperature and below 50°F. (10°C.) its action slows down very considerably. It is also extremely susceptible to the action of *bromide*. When compounded with *alkali carbonates* it gives somewhat slow-working but contrasty developers, while with *caustic*

alkalies its action is very rapid and gives the highest possible contrast. For this reason it is the most widely used developer in technical practice, especially in process work where the highest attainable contrast is essential.

Hydroquinone developers keep reasonably well and are only slowly exhausted.

In normal photographic practice hydroquinone alone is not largely used, but in combination with *metol* it provides a universal developer of outstanding value. By varying the relative quantities of *metol* and hydroquinone and adjusting the quantities of *sulphite* and *carbonate*, almost any desired contrast or rate of development can be obtained (see page 98). The combination can also be used as a fine-grain developer by suitably modifying the formula.

CHLORQUINOL

Chlorhydroquinone. Adurol

Less soluble in cold water than *hydroquinone*, but easily soluble in hot water, rather more energetic in action than hydroquinone and is almost equally sensitive to the action of *bromide*.

Its main use is as a warm-tone developer for papers when heavily restrained with bromide. As a negative developer it has no advantage over *metol-hydroquinone*.

PYROCATECHIN

Catechol. Ortho-dihydroxybenzene

Easily soluble in warm water, chemically closely akin to *hydroquinone* but with some quite special properties, notably the fact that it oxidises very readily and its oxidation products tan gelatine. When used without *sulphite* or with very low *sulphite* content it gives a heavily stained image and tans the gelatine in proportion to the density of the image. This property has led to its use for a number of special purposes for a description of which see page 158.

Pyrocatechin with *caustic alkali* provides the most rapid developers known.

PYROGALLOL

Pyrogalllic acid, Pyro. Trihydroxybenzene

Readily soluble in water, very easily oxidised, and the oxidation products tan gelatine and also colour the film and stain the fingers. Pyrogallol was at one time a universally used developer, but to-day equal results can be obtained by modern developers without the disadvantages of pyrogallol, which has poor keeping qualities.

In combination with metol it has some vogue among press photographers on account of its rapid action and the belief that the yellow stain on the film adds printing quality.

GLYCIN

(Iconyl, Athenon, Kodurol.) Para-oxyphenyl glycin

Almost insoluble in water but dissolves readily in *alkaline* solutions. Oxidises very slowly, very clean working. Used mainly in developers for papers until fine-grain developers assumed importance; now used in combination with other developers for this purpose.

Glycin is very sensitive to *bromide* and also to low temperature; with *alkali carbonates* makes slow-working developers of good keeping properties giving low contrast.

PARA-AMINOPHENOL HYDROCHLORIDE

(Kodelon)

Very soluble in cold water, its principal use is in the preparation of very concentrated developers with *caustic alkalis* which will stand dilution from 20 to 100 times. These solutions keep well and should only be diluted immediately before use.

They work rapidly, are free from fogging properties and do not stain. They are not sensitive to variations of temperature nor do higher temperatures affect their clean working. Hence they are used largely as tropical developers.

Carbonate alkalies should not be used with this substance as they precipitate out the base and prevent the preparation of any but very dilute solutions.

AMIDOL

(Dianol, Dolmi.) *Diaminophenol. 2 : 4 diaminophenol hydrochloride*

Very soluble in water or in sulphite solution. Amidol has the interesting property of acting as a developer in *sulphite solution* without the necessity of adding any *alkali*. The solution is easily prepared but does not keep, although its keeping properties may be somewhat improved by the addition of a weak acid such as *lactic acid*. Solutions of amidol with *bisulphite* have the noteworthy property of beginning their development in the depth of the film and not, as is usually the case, at the surface. So far no practical use appears to have been made of this depth-development effect.

As amidol develops in the absence of *alkali* there is not the excessive swelling of the film that takes place with other developers and amidol is therefore favoured as a tropical or high temperature developer, although it is possible to prepare other developers having like properties without the disadvantage of the poor keeping properties of amidol.

PARAPHENYLENEDIAMINE

1 : 4 Diaminobenzene

Only slightly soluble in water when in the form of the base, but much more soluble as the *hydrochloride salt*. Its particularly valuable property is that it supplies a very fine-grain developer. For various formulae with paraphenylenediamine alone, and in combination with other developer substances, see page 150.

Unfortunately paraphenylenediamine suffers from a number of drawbacks : it is poisonous and has also a very strong tendency to staining and wherever a particle of powder rests it causes a brown spot very difficult to remove.

It will also stain both film and fingers unless very carefully handled.

These many disadvantages have naturally led to attempts at discovering developers which would give fine-grain developers without the troublesome properties. One such material is *orthophenylenediamine* which must, however, be quite free from any trace of the para compound (see page 150).

Paraphenylenediamine forms addition products with various other developing agents, in particular with *hydroquinone* and *pyrocatechin*. To this group belongs *Meritol*, an excellent fine-grain developer which does not possess the disadvantages of paraphenylenediamine.

X.—CHARACTERISTICS OF
A In alkaline carbonate solution. B In caustic

<i>Developer</i>		<i>(1) Fog formation and staining</i>	<i>(2) Sensitivity to temperature</i>	<i>(3) Sensitivity to bromide</i>
METOL	A B C	none appreciable none	slight slight moderate	slight slight moderate
HYDROQUINONE	A B C	none none not suitable	strong moderate —	strong moderate —
PYROCATECHIN	A B C	none none not suitable	strong slight —	strong slight —
PYROGALLOL	A B C	stains not suitable not suitable	moderate — —	moderate — —
AMIDOL	A B C	none not suitable not suitable	moderate — —	moderate — —
GLYCIN	A B C	none none not suitable	very strong strong —	very strong strong —
PARA-AMINOPHENOL	A B C	not suitable none not suitable	slight — —	— slight —
CHLORQUINOL	A B C	none none not suitable	moderate slight —	moderate slight —
PARAPHENYLENE-DIAMINE	C	strong staining properties	moderate	moderate
ORTHOPHENYLENE-DIAMINE	C	none	moderate	moderate

DEVELOPER SUBSTANCES

alkali solution.

C As a fine-grain developer.

(4) Speed of development	(5) Gradation	(6) Keeping properties (a) separately (b) mixed	(7) Properties See page :	(8) Formulae See Nos. :
normal-rapid rapid slow	soft soft soft	a and b good a good, b bad a and b good	74	1, 2
slow rapid —	contrasty contrasty —	a and b good a good, b bad —	75	3, 4, 27, 29
normal rapid —	normal contrasty —	a and b good a good, b bad —	76	11, 12
normal — —	soft — —	a good, b bad — —	77	13
normal — —	normal — —	solutions do not keep — —	78	21
slow rapid —	normal-soft normal —	a and b good a good, b bad —	77	14, 15, 16
— normal-rapid —	— normal-soft —	— a good, b bad —	77	17, 18
normal rapid —	normal contrasty —	a and b good a good, b bad —	76	8, 9
slow	soft	varies with formula	78	48-56
slow	soft	good	79	57-60

PREPARING SOLUTIONS

Chemicals

The first point is to see that the chemicals used are of first-class quality and are obtained from a *dependable dealer*. It is more economical to buy in large than in small quantities, but here the photographer must be guided by the amounts of each chemical he is likely to use, and also by the keeping properties of the chemicals. It must also be emphasised that *no chemical should be kept in paper packets or bags*, in which it will be exposed to the more or less damp atmosphere of the dark-room. The table of chemicals, page 286, indicates clearly how each chemical should be preserved and the nature of its container.

Order of Dissolving

It is of the greatest importance to observe the correct order in dissolving the constituents in any formula which is being made up and to follow the order actually given in the recipe.

Generally it is convenient to *dissolve the sulphite first* as most developing agents are easily oxidised in the absence of this preservative.

An exception to this is the case of *metol* which (see page 74) is only soluble with difficulty in sulphite solutions. Hence when making up developers containing metol, it *should be dissolved before the sulphite*. This has no serious effect on the keeping properties of the developer as metol itself is not very easily oxidised. Many practical workers prefer to dissolve a pinch of sulphite, or a crystal or two of metabisulphite, in the water before dissolving the metol. In such cases the small extra amount of sulphite is ignored, as it is insufficient to upset the balance between sulphite and alkali in the finished developer.

A very important rule in making up developers is to make quite certain that *each constituent in turn is completely dissolved before the next is added.*

Where developers are bought in packet form this rule cannot be obeyed in full because the packets do not contain separate constituents, but usually consist of a small package containing the developing agents and a much larger one containing the other constituents. Even so, the rule can be followed by dissolving the contents of the small packet first and ensuring that the contents are completely dissolved before the contents of the larger packet are added to the solution.

Temperature

With some few exceptions that do not interest us here, all chemicals have the property of dissolving *more rapidly and more easily in warm water than in cold.* Note that we say warm, for it would be a mistake to go too far and to use boiling water. In many cases this would cause decomposition of the materials with the possible precipitation of insoluble residues which would interfere with the properties of the developer and with the development process. It must also be remembered that *too high a temperature accelerates the tendency to oxidation* and so reduces the keeping properties of the solution.

When using warm water in the preparation of developers, etc., it is not necessary to employ the whole volume called for by the formula ; it is preferable to use about two-thirds and then to make up to the required volume with cold water when solution is complete. Many modern formulae are set out in this manner.

The temperature of a solution should not exceed 120°F. (50°C.) unless the instructions with the formula definitely prescribe a higher temperature.

When solution is complete the developer should be *cooled to normal temperature.* By normal temperature is

XI.—FAHRENHEIT, CENTIGRADE AND

F.	C.	R.	F.	C.	R.	F.	C.	R.
+212	+100	+80	+169	+76.11	+60.89	+126	+52.22	+41.78
211	99.44	79.56	168	75.55	60.44	125	51.67	41.33
210	98.89	79.11	167	75	60	124	51.11	40.89
209	98.33	78.67	166	74.44	59.56	123	50.55	40.44
208	97.78	78.22	165	73.89	59.11	122	50	40
207	97.22	77.78	164	73.33	58.67	121	49.44	39.56
206	96.67	77.33	163	72.78	58.22	120	48.89	39.11
205	96.11	76.89	162	72.22	57.78	119	48.33	38.67
204	95.55	76.44	161	71.67	57.33	118	47.78	38.22
203	95	76	160	71.11	56.89	117	47.22	37.78
202	94.44	75.56	159	70.55	56.44	116	46.67	37.33
201	93.89	75.11	158	70	56	115	46.11	36.89
200	93.33	74.67	157	69.44	55.56	114	45.55	36.44
199	92.78	74.22	156	68.89	55.11	113	45	36
198	92.22	73.78	155	68.33	54.67	112	44.44	35.56
197	91.67	73.33	154	67.78	54.22	111	43.89	35.11
196	91.11	72.89	153	67.22	53.78	110	43.33	34.67
195	90.55	72.44	152	66.67	53.33	109	42.78	34.22
194	90	72	151	66.11	52.89	108	42.22	33.78
193	89.44	71.56	150	65.55	52.44	107	41.67	33.33
192	88.89	71.11	149	65	52	106	41.11	32.89
191	88.33	70.67	148	64.44	51.56	105	40.55	32.44
190	87.78	70.22	147	63.89	51.11	104	40	32
189	87.22	69.78	146	63.33	50.67	103	39.44	31.56
188	86.67	69.33	145	62.78	50.22	102	38.89	31.11
187	86.11	68.89	144	62.22	49.78	101	38.33	30.67
186	85.55	68.44	143	61.67	49.33	100	37.78	30.22
185	85	68	142	61.11	48.89	99	37.22	29.78
184	84.44	67.56	141	60.55	48.44	98	36.67	29.33
183	83.89	67.11	140	60	48	97	36.11	28.89
182	83.33	66.67	139	59.44	47.56	96	35.55	28.44
181	82.78	66.22	138	58.89	47.11	95	35	28
180	82.22	65.78	137	58.33	46.67	94	34.44	27.56
179	81.67	65.33	136	57.78	46.22	93	33.89	27.11
178	81.11	64.89	135	57.22	45.78	92	33.33	26.67
177	80.55	64.44	134	56.67	45.33	91	32.78	26.22
176	80	64	133	56.11	44.89	90	32.22	25.78
175	79.44	63.56	132	55.55	44.44	89	31.67	25.33
174	78.89	63.11	131	55	44	88	31.11	24.89
173	78.33	62.67	130	54.44	43.56	87	30.55	24.44
172	77.78	62.22	129	53.89	43.11	86	30	24
171	77.22	61.78	128	53.33	42.67	85	29.44	23.56
170	76.67	61.33	127	52.78	42.22	84	28.89	23.11

REAUMUR DEGREES OF TEMPERATURE.

F.	C.	R.	F.	C.	R.	F.	C.	R.
+83	+28.33	+22.67	+41	+5	+4	-1	-18.33	-14.67
82	27.78	22.22	40	4.44	3.56	2	18.89	15.11
81	27.22	21.78	39	3.89	3.11	3	19.44	15.56
80	26.67	21.33	38	3.33	2.67	4	20	16
79	26.11	20.89	37	2.78	2.22	5	20.55	16.44
78	25.55	20.44	36	2.22	1.78	6	21.11	16.89
77	25	20	35	1.67	1.33	7	21.67	17.33
76	24.44	19.56	34	1.11	0.89	8	22.22	17.78
75	23.89	19.11	33	+0.55	+0.44	9	22.78	18.22
74	23.33	18.67	32	0	0	10	23.33	18.67
73	22.78	18.22	31	-0.55	-0.44	11	23.89	19.11
72	22.22	17.78	30	1.11	0.89	12	24.44	19.56
71	21.67	17.33	29	1.67	1.33	13	25	20
70	21.11	16.89	28	2.22	1.78	14	25.55	20.44
69	20.55	16.44	27	2.78	2.22	15	26.11	20.89
68	20	16	26	3.33	2.67	16	26.67	21.33
67	19.44	15.56	25	3.89	3.11	17	27.22	21.78
66	18.89	15.11	24	4.44	3.56	18	27.78	22.22
65	18.33	14.67	23	5	4	19	28.33	22.67
64	17.78	14.22	22	5.55	4.44	20	28.89	23.11
63	17.22	13.78	21	6.11	4.89	21	29.44	23.56
62	16.67	13.33	20	6.67	5.33	22	30	24
61	16.11	12.89	19	7.22	5.78	23	30.55	24.44
60	15.55	12.44	18	7.78	6.22	24	31.11	24.89
59	15	12	17	8.33	6.67	25	31.67	25.33
58	14.44	11.56	16	8.89	7.11	26	32.22	25.78
57	13.89	11.11	15	9.44	7.56	27	32.78	26.22
56	13.33	10.67	14	10	8	28	33.33	26.67
55	12.78	10.22	13	10.55	8.44	29	33.89	27.11
54	12.22	9.78	12	11.11	8.89	30	34.44	27.56
53	11.67	9.33	11	11.67	9.33	31	35	28
52	11.11	8.98	10	12.22	9.78	32	35.55	28.44
51	10.55	8.44	9	12.78	10.22	33	36.11	28.89
50	10	8	8	13.33	10.67	34	36.67	29.33
49	9.44	7.56	7	13.89	11.11	35	37.22	29.78
48	8.89	7.11	6	14.44	11.56	36	37.78	30.22
47	8.33	6.67	5	15	12	37	38.33	30.67
46	7.78	6.22	4	15.55	12.44	38	38.89	31.11
45	7.22	5.78	3	16.11	12.89	39	39.44	31.56
44	6.67	5.33	2	16.67	13.33	40	40	32
43	6.11	4.89	1	17.22	13.78			
42	5.55	4.44	0	17.78	14.22			

meant that temperature at which processes such as development and the like should be carried out, and that is 65°F. (18°C.). A degree or two above or below this temperature is not of great importance, but a difference of 5° must be taken into consideration in all careful work and every endeavour should be made to keep the temperature of the solutions at 65°F. when in use.

It should also be noted that where solutions have been over-cooled, or when they have been kept in a cold place, *crystallisation* of some of the constituents may occur; this should be guarded against as much as possible.

Manipulation

Solutions should not be prepared in the vessels in which they are to be used, e.g., tanks, dishes, etc., but in separate vessels. *Glass or porcelain jars or wide-mouthed bottles are convenient, but metal receptacles should not be used*, and this applies particularly to iron, copper, aluminium, etc.

To ensure quick solution and perfect mixing the solution should be well *stirred or shaken*. Stirring is best and for small volumes a glass rod may be used. A hard wood stirrer is best for large volumes. The same stirrer should not be used for developer and fixing bath alike, even though care be taken to clean it after use; a separate stirring rod should be provided.

Tap-water

Unless a formula specifically calls for distilled water, the usual domestic supply can be used for almost all photographic solutions and therefore for developers.

Where the water is very *hard* it can be treated as described on page 71, so that no precipitation of lime salts occurs. If this is not practicable, then the solution should be allowed to settle and the clear supernatant liquor decanted off. This procedure is sufficient in the case of most developers.

Where a perfectly clear developer is essential *filtration*

must be resorted to, using a funnel and filter paper. Where large volumes have to be handled the funnel and filter paper are too slow and a quick and cheap method is to use an old-fashioned jelly-bag held in a hard wood frame over the tank which is to hold the developer. If the jelly-bag is unobtainable, then filter cloth can be fixed to the frame so as to form a shallow bag and used in the same way. Whether the jelly-bag or filter cloth is used, be sure that they are well washed with hot water after use.

Saturated Solutions

By a saturated solution is understood a solution of any chemical which at a particular temperature is *incapable of dissolving any more of that chemical*. In general, normal room temperature, that is about 60°F. (15°C.), is understood.

The preparation of a saturated solution is a comparatively simple matter and is carried out as follows: The water or other solvent is *slightly warmed* and the substance to be dissolved is added with *constant stirring* until no more is dissolved and an undissolved residue remains at the bottom of the vessel. That is a sign that the solution is saturated. The solution is now allowed to *cool down* to room temperature; in doing so a further quantity of the substance will crystallise out. When the solution has reached room temperature it can be filtered or decanted from the residue.

It will be realised that the amount of salt required to saturate a solution is dependent on temperature, but in photography we are only interested in "cold" saturated solutions, that is solutions at room temperature.

Percentage Solutions

A certain amount of misunderstanding exists in some quarters as to how a solution containing a prescribed percentage of a particular constituent should be prepared.

Suppose we want a 10 per cent solution of potassium

bromide, we weigh out 10 parts of the bromide, it may be 100 grains or 10 grams, and we dissolve it, not in the full quantity of water required, but in about three-quarters of the amount. When the bromide is wholly dissolved we then make up the liquid to the correct volume. If we have weighed out 100 grains, then we require 1,000 grains of water by weight. That is, $2\frac{1}{4}$ ounces within a few minims. If we have taken 10 grams we require exactly 100 cubic centimetres, so as to get a 10 per cent solution by weight. It is quite true that had we dissolved 10 grams of bromide in 100 c.c. of water, the error would have been a small one and not of any significance in photographic operations, but we should not have made up an exact 10 per cent solution, and it is better to be exact than careless.

The use of correct weight per cent solutions is particularly helpful when it is desirable to obviate the weighing of numerous very small quantities. It is much easier and quicker to measure out a few minims or a cubic centimetre or so of solution than to weigh a grain or the tenth of a gram, provided always that the photographer uses the metric system. It has to be admitted and is clear from the following example that when working with the Avoirdupois system the use of percentage solution is not quite so convenient.

Suppose we require a solution having the composition

Potassium ferricyanide	...	...	...	100 grains	5 grams
Potassium bromide	...	...	...	30 grains	1.5 grams
Water to make	...	...	...	40 ounces	1,000 c.cm.

If we have stock solutions of 10 per cent potassium ferricyanide and 10 per cent potassium bromide, we make our solution up by taking:

Potassium ferricyanide, 10% solution	...	2 ounces	50 c.cm.
Potassium bromide, 10% solution	...	5 drams	15 c.cm.
Water	...	37 oz. 3 drms.	935 c.cm.

Total volume	...	40 ounces	1,000 c.cm.
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Certain chemicals which keep well in solution can also be kept on the shelves in correct per cent solutions.

Dilute Solutions

For preparing dilute solutions of known strength from concentrated solutions it is, of course, essential that the percentage content of the concentrated solution be known. If then we are working on the metric system using cubic centimetres, the procedure is very simple.

Suppose we want a 10 per cent solution and our concentrated solution contains 40 per cent. We take 10 c.cm. of the concentrated solution and add water to make the total volume 40 c.cm., then we have 40 c.cm. of a 10 per cent solution. If our concentrated solution contained only 32 per cent then we should still take 10 c.cm. but we should add water to make 32 c.cm. Hence using metric volumes we take the number of c.cm.'s representing the percentage we require in the dilute solution and we add water to make up the number of c.cm. equal to the percentage of the concentrated solution.

With English measures it is not so simple unless we confine our volumes to minims or drams, when we can use the same rule ; hence to make a 10 per cent solution from a 40 per cent we should take 10 drams of the 40 per cent solution and add water to make 40 drams (5 ounces) and so on.

Water up to . . .

In many formulae we find the instruction " water up to " or " water to make " and then the required volume is given. This is always a clear direction to dissolve the ingredients called for by the formulae in a lesser volume of water, generally about two-thirds, and then when solution is complete to add further water to bring the whole to the required volume.

As already mentioned, it is often the custom in modern formulae to direct that a certain volume of the water shall be used at a temperature of 120°F. (50°C.). In such formulae the total volume of water required is usually indicated at the bottom of the list of ingredients accompanied by the sentence, "water to make," or sometimes "cold water to make." The meaning of such directions should be quite clear from the above account.

Weights and Measures

A glance at any of the formulae in this book will show that the quantities are given first in English Avoirdupois, and then in the metric system. It is to be noted that the figures in the two systems are not interchangeable, that is to say, a formula must not be compounded by weighing some of the constituents on the English system and some on the metric. The finished solutions, whether made by the English or the metric system, will be similar.

It should also be noted that the English pint, quart and gallon are not the same as the American measures of the same names. The United States' gallon has 128 ounces against the English gallon of 160 ounces. Hence, in the United States, the pint is 16 ounces, the quart is 32 ounces and the gallon is 128 ounces. Whereas in England the pint is 20 ounces, the quart is 40 ounces and the gallon is 160 ounces.

The conversion of British weights and measures to metric, or *vice versa*, if carried out in the usual way by using exact factors, is a somewhat troublesome procedure owing to the fractions or decimals involved. As a result various *conventional conversion factors* are employed which, while not exact, are sufficiently correct for all practical purposes. One of these conventions has been used in this book throughout (except in a number of cases where the author of a formula laid down definite Avoirdupois and metric alternatives of his own).

For example, it will be seen that the *Avoirdupois ounce* is

XII.—ENGLISH, AMERICAN AND METRIC EXACT VALUES

1.—British Imperial Quart to U.S. Quart

Grains, Ounces or Pounds per British Imperial Quart (40 fluid ounces) multiplied by 0.833 = Grains, Ounces or Pounds per U.S. Quart (32 fluid ounces).

2.—British Imperial Quart to Litre

Grains per British Imperial Quart multiplied by 0.05696 = grams per Litre
Ounces „ „ „ „ „ by 24.92 = grams per Litre
Pounds „ „ „ „ „ by 398.7 = grams per Litre

3.—Litre to British Imperial Quart

Grams per Litre multiplied by 17.54 = grains per British Imperial Quart
„ „ „ „ by 0.0401 = ounces „ „ „
„ „ „ „ by 0.002506 = pounds „ „ „

4.—U.S. Liquid Measure to Litre

Grains per 32 ounces multiplied by 0.06847 = grams per Litre
Ounces „ „ „ „ by 29.96 = grams „ „
Pounds „ „ „ „ by 479.3 = grams „ „

5.—Litre to U.S. Measure.

Grams per Litre multiplied by 14.6 = grains per 32 ounces
„ „ „ „ by 0.03338 = ounces „ „ „
„ „ „ „ by 0.002086 = pounds „ „ „

6.—British Imperial Liquid Quart to U.S. Liquid Quart

Ounces (fluid) per British Imperial Quart multiplied by 0.8 = Ounces (fluid) per U.S. Quart.

7.—British Imperial Liquid Quart to Litre

Ounces (fluid) per British Imperial Quart multiplied by 25.00 = Cubic Centimetres per Litre.

8.—Litre to British Imperial Liquid Quart

Cubic centimetres per Litre multiplied by 0.03999 = Ounces (fluid) per British Imperial Quart.

9.—U.S. Liquid Quart to Litre

Ounces (fluid) per 32 ounces multiplied by 31.25 = cubic centimetres per Litre.

10.—Litre to U.S. Liquid Quart

Grams per Litre multiplied by 0.032 = Ounces (fluid) per 32 ounces.

XIII.—AVOIRDUPOIS AND METRIC WEIGHT EQUIVALENTS

<i>Pounds</i>	<i>Ounces</i>	<i>Grains</i>	<i>Grams</i>	<i>Kilograms</i>
1.0	16.0	7000.0	453.6	0.4536
0.0625	1.0	437.5	28.35	0.02835
		1.0	0.0648	
	0.03527	15.43	1.0	0.001
2.205	35.27	15430.0	1000.0	1.0

XIV.—BRITISH LIQUID AND METRIC MEASURE EQUIVALENTS

<i>Gallons</i>	<i>Quarts</i>	<i>Fl. Ounces</i>	<i>Fl. Drams</i>	<i>Cubic cent.</i>	<i>Litrés</i>
1.0	4.0	160.0	1280.0	4546.0	4.546
0.25	1.0	40.0	320.0	1136.0	1.136
		1.0	8.0	28.41	0.02841
	0.003125	0.125	1.0	3.551	0.003551
		0.03520	0.2816	1.0	0.001
0.2200	0.8800	35.20	281.6	1000.0	1.0

XV.—U.S. LIQUID AND METRIC MEASURE EQUIVALENTS

<i>Gallons</i>	<i>Quarts</i>	<i>Fl. Ounces</i>	<i>Fl. Drams</i>	<i>Cubic cent.</i>	<i>Litres</i>
1.0	4.0	128.0	1024.0	3785.0	3.785
0.25	1.0	32.0	256.0	946.3	0.9463
		1.0	8.0	29.57	0.02957
0.000975	0.0039	0.125	1.0	3.697	0.003697
		0.03381	0.2705	1.0	0.001
0.2642	1.057	33.81	270.5	1000.0	1.0

taken as being equivalent to 25 *grams* and the *gram* as being equal to 20 *grains*, whereas their true equivalents are 28.35 *grams* to the ounce and 15.43 *grains* to the *gram* respectively. Although such differences may appear appreciable, in actual practice that is not so because the relative proportions of solid to liquid in the two formulae, that is, in the Avoirdupois and the metric respectively, are much more nearly correct than would appear at first sight, hence the percentage values of the various solutions, when made up in accordance with this convention are sufficiently accurate.

METHODS AND APPARATUS

There is a bewildering choice of possibilities for the development of photographic negative materials. One has the choice of hundreds of formulae, dozens of methods and also a variety of apparatus. The simplest of the questions to be answered is which method to employ :

- (1) *Dish or tray development.*
- (2) *A daylight developing tank.*
- (3) *Tank development.*

Which of these methods will be the most practical depends upon the character of the negative material and the quantities that have to be handled.

Dish or tray development is suitable for single *plates or flat films*. Roll film or film for the miniature camera should not be dish developed; such a method is unpractical and will almost certainly result in scratches or streaks along the length of the film, in addition to which the whole process is dirty and unpleasant.

For the development of the *single roll film*, including of course those from the miniature camera, the daylight developing tank is much used to-day. This is generally in the form of a small cylindrical tank, with the necessary arrangements for keeping the film from contact with other parts of the emulsion-coated surface, and takes just sufficient developer solution for the correct development of one film.

For the handling of both *plates and films in quantity*, tank development is now the general rule everywhere, if only for the reason that it allows a very large number of negatives to be developed under identical conditions.

Individual Development or Development by Time ?

In earlier days the question of individual development played a great part in the selection of development methods.

By individual development was meant the possibility of influencing the character of the negative by *varying the time of the development* at the desire or caprice of the photographer. Such a procedure necessitates observing the building up of the negative image during the development process, and for this reason dish or tray development was preferred to all other methods. The opposite of individual development was *development by time*, in which all negatives were developed for a definite time without special control.

It was argued on behalf of individual development that one could correct errors of exposure and on the one hand control the gradation of the negative to suit the positive material, while on the other it was possible to vary the contrast range of the actual object photographed within comparatively wide limits.

In order to see just how far these claims are true, we must examine what the real possibilities of influencing the negative characteristics in and during development are, and whether there is any true foundation for such claims.

We already know (page 33) that time of development has an influence on gradation and density or blackening. The longer one develops the steeper the gradation grows (higher gamma value), until a definite limit is reached (gamma infinity). If we set out the growth of blackening of the negative for different development times in the form of a diagram showing the various steps of blackening as on page 27, we shall reveal the actual character of the development process. We shall see graphically that with increasing time the steps are steeper, and that finally they form a kind of platform (= maximum blackening of the negative), and the density or blackening no longer increases.

The possibility of controlling gradation in this manner was of importance in the early days of photography because the photographer had *only one type of paper* at his disposal, and that paper had *only one gradation*. In those far-off days, when only *albumin paper* could be obtained, the photographer

aimed at obtaining a negative which would produce a good print on that paper; that meant that he must produce a negative that was neither too hard nor too soft. Hence when his subject was contrasty he *developed for softness* by giving a comparatively *short* development, but when his subject lacked contrast he had to give a *long development* and so obtain a medium *contrast* negative. His desire for a developer of a versatile character and for a method which gave reasonable control of the negative is therefore understandable. He preferred to work with a developer which changed its properties on dilution, on variation of the relative quantities of its constituents, and which produced different results according to the time of development applied.

The position of the modern photographer is quite different. He has at his disposal a range of *papers of almost infinite variety of contrasts* and can therefore produce a good print from any negative whether it be hard or soft in gradation. Moreover the possibility of the individual treatment of a single exposure is almost non-existent because his roll film or miniature film provides a *series of exposures* which it is, in general, quite impracticable to handle separately. Hence the question of individual development or development by time is already answered.

“ Normal ” Negatives

Experience has shown that no compromise is called for because one can obtain constant and regular results if the development process is properly handled. Such will be the case when, for example, we obtain a negative of *normal gradation* from an exposure made on an object exhibiting an average range of light intensities. That is a negative which will give a good print or enlargement on a paper of normal gradation. Such conditions are fulfilled by a negative developed to a *gamma of 0.8 to 1.0*.

The various formulæ in this book, when used for the times

indicated in each case, produce negatives having this characteristic. Where the negatives are of contrasty objects a soft gradation paper is used, and a hard gradation paper for soft negatives. Hence what the earlier photographer sought to obtain, often unsuccessfully, by manipulating the development process is to-day more easily and certainly obtained by choosing the *right grade of printing or enlarging paper*.

Compensating Development

In a somewhat similar manner photographic technology to-day deals with another question, namely the rectification of errors in exposure. How it does this can be made clear by a reference to our blackening staircase or steps on page 25.

What effect has an error in exposure in the building up of the blackening of our negative ? If we give too short an exposure only the lower part of our staircase will be developed; with a longer exposure the scale will be extended towards the upper part.

The great latitude toward exposure of modern negative material permits of so long a blackening scale that there is actually room for quite a series of errors of exposure. The actual differences between negatives which have received different exposures is *not in gradation*, as can be seen on page 31, for the steepness of the steps is the same over the whole range, but in the fact that the densities or blackening of the longer exposed negative lies *higher up the scale* than is in the case with short exposures. In printing this means that negatives of short or long exposure can be printed on the *same paper*, but those with the heavier or higher densities or blackening will require a *longer exposure* in printing as compared to those which have had a short or normal exposure.

We can now ask what effect *development time* has on the variously exposed negatives ? If we compare the range of

blackening of a negative which has had a short development time, with another which has received normal development, we shall see that *short development* has given us a weaker result and that *blackening is less*. That means that we must use a contrasty paper for printing and a short exposure. So far as the finished prints are concerned there will be no serious difference between them, and the same will apply in respect of errors of exposure, whatever variations we may adopt in the development process.

In fact, the great latitude in exposure of modern sensitive material is sufficient itself to bridge over errors in exposure in the great majority of cases. There are some special exceptions which we shall discuss in the section dealing with developer formulae (page 127), but as a general rule it will be well to avoid any tricks or special artifices in the actual development.

Dish or Tray Development

In early days this was the most widely-used method of development. To-day it finds application in the handling of single plates or films. We have already seen that it affords the possibility of observing the growth of the image during development and, to some extent, influencing the process. Let us gather together the various factors that can influence the character of the negative and arrange them as a short set of rules.

- (1) A strongly *diluted developer* results in a *soft negative*.
- (2) Increased *time* of development increases the *contrast*.
- (3) The stronger the *concentration* of the developer the more quickly it will develop, and the more *speedily* will high contrast be reached.
- (4) With home-compounded developers increasing the *alkali* content provides a means of accelerating development *time*, and therefore *contrast*. This procedure requires great care, otherwise there is the danger that fog will be produced.

The way in which the properties of a developer can be varied by altering its composition is shown in Table XVI.

The table shows how it is possible to obtain nine variants of this particular developer, so that almost every type of result from a very soft to a hard gradation can be obtained.

A dash in the table denotes no change in the standard formula under the particular heading of the column.

It will be seen that in No. 1 the hydroquinone content is 60 grains (3 grams) and the soda is 2 ounces (50 grams) and a very soft working developer is obtained. No. 2 is somewhat more contrasty as only the hydroquinone is altered; in No. 3 the hydroquinone is increased to 100 grains (5 grams) and the soda content is as in No. 1.

In numbers 4 and 5 similar variations are made and here the higher hydroquinone content results in more brilliant, that is somewhat harder, results. In the variations 5-9 the chemical composition of the developer is not altered but the degree of dilution is varied and so an increasing degree of brilliance or hardness is attained.

XVI.—VARYING OF FOCAL-UNIVERSAL M-Q DEVELOPER 7

Effect		Quantity of Hydroquinone	Quantity of Alkali	Degree of Dilution	Minutes of Developing
Soft	1	60 grains or 3 grams	2 ounces or 50 grams	1 : 7	5
	2	60 grains or 3 grams	—	1 : 7	5
	3	100 grains or 3 grams	2 ounces or 50 grams	1 : 5	5
Normal	4	100 grains or 5 grams	—	1 : 5	5
	5	—	—	1 : 10	5-6
	6	—	—	1 : 7	6-7
	7	—	—	1 : 5	7
Hard	8	—	—	1 : 1-2	4-5
	9	—	—	Undiluted	3-4

The *temperature* at which development is carried out is of fundamental importance, no matter what method of development is used. The *normal* temperature for development is 65°F. (18°C.), and every effort must be made to ensure that this temperature is maintained, for temperature exerts a great influence over the development process.

A *low temperature* slows down development and hinders the building up of density, while a *high temperature* accelerates the process and introduces the danger of fogging.

Dishes or trays for developing should preferably be of *glass, porcelain or stainless steel* and should be rigorously reserved for their special purpose. They should never be used for other photographic purposes such as *fixing*, for which separate vessels should be provided. If the dishes in use are of the same size and material they should be marked with a waterproof paint, D for developing, F for fixing, so that there shall be no confusion and no mixing of dishes.

Plates or films for development are laid into the dish sensitive *face upward*, and care must be taken to ensure that the developer flows evenly and quickly over the whole of the surface. This is best achieved by *tilting* the dish slightly so that the solution accumulates at the lower end, then placing the plate or film in the dish, quickly lowering the raised end so that a wave of developer flows quickly but smoothly over the whole of the plate or film surface. A look-out should be kept for *air-bubbles*, and if one or two are seen they should be gently removed by using the finger-tip. A better method is to have a small soft *brush* kept specially for the purpose.

The dish should be kept in gentle movement, by *rocking*, during the whole time of development to ensure even action of the developer. This is particularly important when the developer contains *potassium bromide* (see page 69), as it can accumulate locally in the developing film and cause uneven development if the developer does not flow freely over the developing surface.

One can now observe the beginning and the progress of the development process, and if the necessity arises, make such corrections as seem called for. In the normal handling of negatives we may meet with the three following possibilities: (1) Correct exposure. (2) Under-exposure. (3) Over-exposure.

(1) *Correct Exposure.* The image develops in a normal manner, the negative has been correctly exposed. As we shall see later (see page 166), the appearance of the first trace of the image and the way in which the image builds up varies somewhat with different developers, but the normal order of appearance and development is as follows.

The first to appear are the *high lights*, those parts of the subject photographed which were most brilliantly lit; next come the *well-lit parts*, then the *half tones* and finally the *details of the shadows*, that is, the darkest or least lit portion of the picture.

The density and gradation of the negative can be judged by looking through the plate or film and the right moment chosen for stopping the development process, that is, the moment that it has reached the desired character. If the negative appears too soft or thin, development is continued until every important detail in the picture is visible. If greater contrast is required, then the time of development will be increased until it is obtained.

(2) *Under-Exposure.* This is shown during development by the appearance of the high lights, then *much more slowly* the other details and the *half tones* appear, but the *details in the shadows* refuse to appear even after long development.

A badly under-exposed negative cannot be saved by any manipulation of the developer. Those parts of it which received no exposure or an insufficient amount cannot be developed, for there is nothing there to develop. It is therefore quite *wrong* in such a case to attempt the use of a concentrated developer, the effect of which will be to

exaggerate the contrast of that part of the image which has developed without in any way improving the rendering of shadow detail.

The old-fashioned remedy of diluting the developer is equally *fruitless*, for there is nothing in the negative to be saved. At the best all that we can do is to make use of some method of increasing contrast (see page 240), by the choice of a special grade of printing paper.

(3) *Over-Exposure*. This shows itself in development by the *whole image flashing up quickly*, and not merely the high lights: that is always an indication of over-exposure.

It is not an indication to stop development; on the contrary, the process should be continued until the negative is fully developed right through. True, the image will be dense and the whole negative dark but, thanks to the latitude of modern materials, the gradation will be a usable one. If the development be stopped too soon the negative will be too flat.

Judging the Negative. A certain amount of experience is necessary in order to judge correctly the character of a negative during development. The creamy *silver bromide* in the film is *deceptive* and appears to increase the covering power of the developed silver. When a negative has been fixed and the undeveloped silver bromide removed, the negative looks much less dense than it did before, and appears to have "gone back" or retrogressed. Hence the old and well-known rule that the *negative examined by the dark-room light must always appear somewhat denser than is actually required in its finished state*.

Owing to the high general and colour sensitivity of modern materials, the negative should *never be exposed for any length of time to the dark-room light*. A short glimpse should suffice to indicate the nature of the control required. Although we speak of safelights, the term is a relative one and even the safest red light can fog an *orthochromatic* film if it is exposed long enough.

With *panchromatic* materials control is difficult, even with a green safelight. The usual green safelight prescribed will give sufficient illumination to enable one to move about the dark-room in safety, and to see where apparatus is, but not sufficient to allow of judging a negative. Hence for panchromatic material either time development should be used (see page 94), or a desensitiser employed (see page 205).

The emulsion layer on plates or films is very easily *damaged*, either mechanically or chemically, at every stage of the photographic process. It should be a rule *never* to *touch the emulsion surface* with the fingers; a glass negative should always be held *by the edges*—if it is a small one, then the thumb and forefinger should suffice and only the edges of the negative be touched. Flat film or roll film negatives must be held by an edge which is free from any image.

If the face of an undeveloped plate or film is touched there is always the danger of *markings* being caused either through the natural oiliness of the skin, perspiration or plain dirt or dust. In any case there is likely to be some interference with the process of development.

In the *wet state* the emulsion is very easily damaged and the greatest care must be taken to ensure that it does not come into contact with anything that could affect it.

Even the *dried negative* can easily be marked and spoiled by being touched with moist or dirty fingers and such markings are particularly troublesome when enlargements have to be made.

Daylight Development

The difficulty of developing a long length of film in a dish has already been mentioned, and although *special long narrow dishes* have been produced for the purpose of developing films, they have not proved popular. In addition, the modern fine-grain developers call for a long development time, and if the dish or developer container is to be

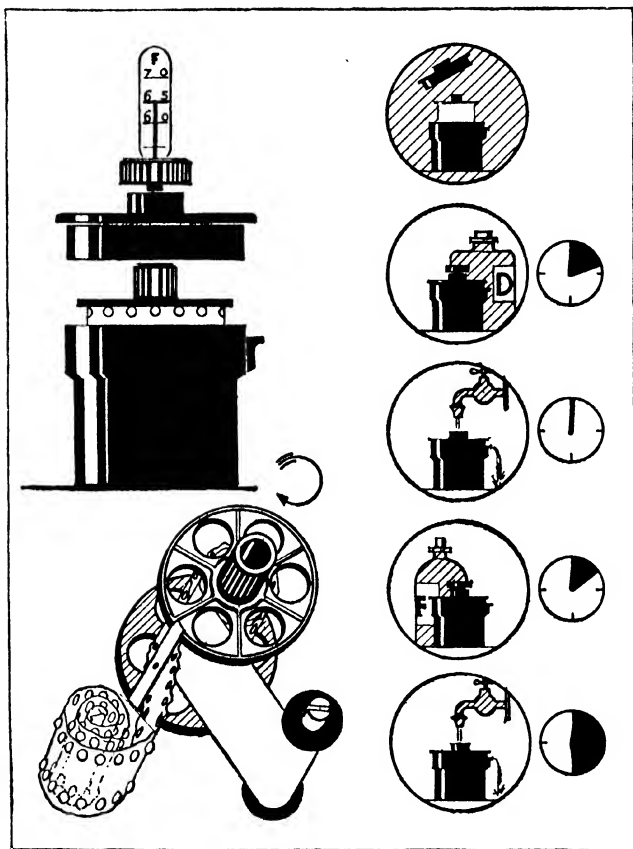
kept in constant movement while development is taking place, a great deal of time is lost.

For similar reasons the *drum-type of developing machine* has not achieved any great amount of popularity. It consists of a glass drum or barrel mounted on metal bearings. Under the drum is a dish which contains the developer solution. The film is threaded on the drum and as this revolves so the film, passing through the developer, is developed. The drum has to be kept in movement during the whole of the process, and one real disadvantage is that for much of the time the developing film is exposed to air which can give rise to a number of troubles of which *aerial fog* is only one.

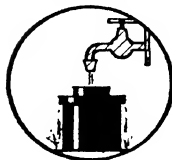
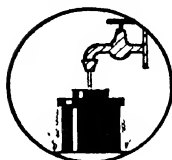
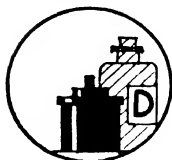
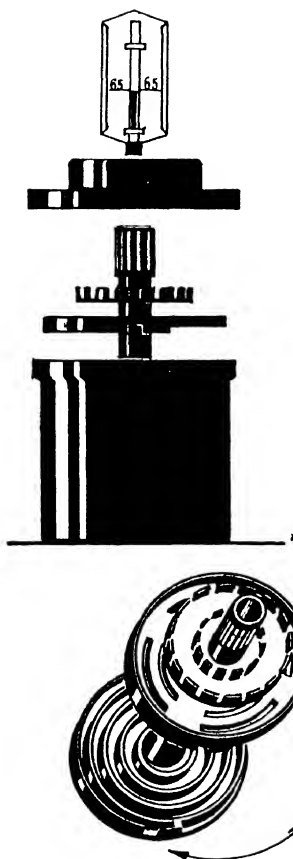
A notable solution of the whole problem lies in the many *daylight developing tanks* which have been evolved. The essential principle of these is that the film is developed whilst wound up in spiral form, and that the daylight developing tank only requires sufficient solution to develop a single film. Some of the earlier models were not intended for daylight use, but were used or at least loaded in the dark-room ; the general principles were, however, the same. Not only is the film wound in spiral form, in which it occupies minimum space, but the conditions must be such that the *turns of the film do not touch one another* and that the developing solution has *free access to both the back and the front of the films*.

In practice this is achieved in two different ways: by means of an apron or band which serves to keep the turns of the film separate, or by a spiral lead in and guide attached to the central bobbin.

The apron or band type. This was the earliest on the market, the film and the apron or band are wound up together on the centre spool of the tank. The apron, which generally consists of *celluloid*, has projections on its surface which serve to support both the front and the back of the film to be developed, and also ensure the necessary space for the flow of the developer; the apron is often perforated



DAYLIGHT DEVELOPING TANK, APRON OR BAND TYPE
(See page 107)



DAYLIGHT DEVELOPING TANK, SPIRAL GUIDE TYPE
(See page 107)

to help in this direction. The tank itself is usually made of pressed bakelite or some similar *artificial plastic* and has a light-tight lid or cover (see page 104).

The spiral guide type. Here the apron or band is dispensed with, and the film is held in position during development by spiral leads or guides forming part of the central bobbin. Small projections occur at regular intervals round the inside of the spirals and so hold the film in position, and also allow of the free circulation of the developer. This principle permits of universal tanks which can be used for the development of *films of various sizes*: to this end the spiral guides are made adjustable and can be fixed in any desired position on the centre axle (see page 105).

The *capacity* of such tanks is about 20 ounces (500 c.cm.), but those for miniature films take a much smaller quantity and are therefore very economical.

The charging of the tank must be done in the dark-room, but once the light-tight cover has been adjusted to the tank the rest of the procedure can be carried out in daylight, hence the name of daylight development.

Most models are supplied with inlet and overflow so that the film can be rinsed with water when development is completed, and then the *fixing solution* introduced without necessity of opening the tank or using the dark-room.

Certain types are available which actually permit the *loading operation* to be carried out in *daylight*, and so dispense with the dark-room altogether. Although the idea is alluring, it has to be admitted that these tanks are not so simple to operate, they are somewhat less safe and they are distinctly more expensive (see page 108).

Roll film is somewhat more difficult to manipulate in daylight developing tanks than 35 mm. (miniature) film on account of the red or green black paper.

The film should be loaded into the tank *already filled with developer*: not the other way round.

Airbells and uneven development must also be guarded against. When developing in a dish the airbells or air-bubbles can be seen and removed. In the daylight developing tank that is impossible, but the possibility of airbells is real. They are, however, easily dealt with by giving the tank a *short but fairly strong shake just as development begins.*

The best safeguard against uneven development is always to use *fresh developer* and to ensure that it is well mixed.

It is not convenient to maintain the tank in constant movement during development, but a *certain amount of agitation* is essential. In most cases this is brought about by revolving the axle upon which the film is wound. If this is not possible, then the tank must be gently shaken to and fro. This should be done *at intervals of 2-3 minutes* during the whole of the time of development.

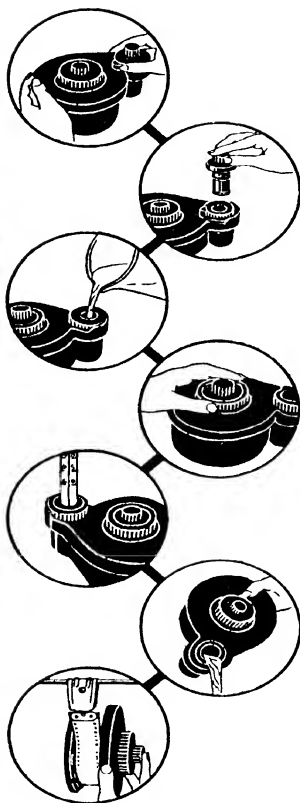
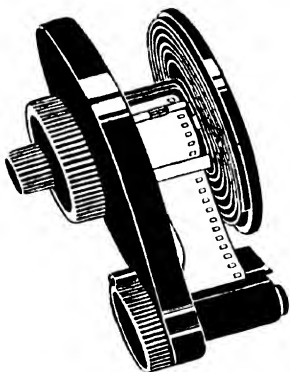
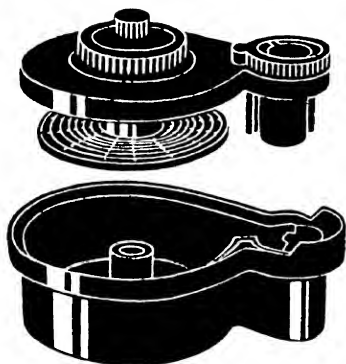
There exists *apparatus 'which automatically agitates* the spool, either by means of a small water turbine or a tiny electric motor driving a small pulley on the spool, the connection being made by a rubber band. The cost of such a device is, however, somewhat high and, as a result, such mechanical agitation has not been widely adopted.

Page 104: DAYLIGHT DEVELOPING TANK, APRON OR BAND TYPE. Left top: the complete apparatus—thermometer, knob for agitating film during development, cover, spool and tank. Left bottom: method of spooling with film and apron, the red-black paper being previously removed. Right from top to bottom: processes of the development: (1) The spool is placed in the tank in the dark-room. (2) When the developer has been added and the cover closed, the tank can be brought into bright light and development proceeded with. (3) The developer is poured away and a short rinse given. (4) The fixing bath is introduced and 10 minutes fixing given. (5) Washing for 30 minutes follows the fixing. The last four processes can be carried out in daylight.

Page 105: DAYLIGHT DEVELOPING TANK, SPIRAL GUIDE TYPE. Left top: the assembling of the tank. Left bottom: spool with spiral guide for the film. The film is wound on to the spool after the red-black paper has been removed. Right from top to bottom: steps in the process: (1) Placing the film in the tank in the dark-room. (2) Development. (3) Rinse between development and fixation. (4) Washing. The last three processes can be carried out in daylight.

TYRRE

DAY



DAYLIGHT-LOADING DEVELOPING TANK.

(See page 109)

Page 108: [DAYLIGHT DEVELOPING TANK. This particular model is designed for daylight processing of 35 mm. black-and-white film when it is in daylight-loading magazines. To use the tank, the film leader must extend outside the film magazine. The film can then be loaded, developed, rinsed, fixed and washed in the tank in daylight. The tank has two chambers, into one of which the spool of film to be developed is placed, while the other contains a spiral round which the film is wound before development. To load the tank, the cover is raised as shown in the top drawing on the left. The film magazine is inserted into the magazine chamber and the film leader threaded into the spiral as shown in the bottom drawing on the left. The cover is replaced on the tank and the film wound from the magazine on to the tank reel by turning the reel collar. Now the magazine collar is rotated (*first drawing on the right*) to cut off the film from the spool by means of a stationary knife located within the tank. By lifting out the magazine knob the empty magazine can be removed (*second drawing on the right*). The developer is poured into the opening at the top of the magazine chamber and the film agitated during development by rotating the reel collar (*fourth drawing*). The temperature can be measured during development by inserting a thermometer into the magazine chamber. After development is complete, the developer is poured out, the tank filled with water for rinsing and then with fixing bath. To dry the film, fasten the end, while it is still on the reel, with a film clip suspended from the ceiling or a shelf and unwind the film as shown in the last drawing on the right.

Tank Development

Tank development renders possible the developing of numbers of plates or films simultaneously. It is therefore essential for the mass handling of negative material, and is of particular importance in the developing and printing industry which to-day has assumed such large proportions.

An intermediate step between the daylight development tank and tank development is supplied by small tanks which can accommodate one, or at most a very few films (see page 119). They have a disadvantage in that a proportionally larger volume of developer is required than in a daylight tank, but have the advantage that they do permit some control of the development process, though this involves the examination of the plate or film by withdrawing it in its holder from the tank. In the case of plates these small tanks take the place of the daylight tank for films.

In the larger tanks *50 or more negatives* can be developed at a time. Such tanks usually have a capacity of about *10 gallons* (45 litres), but the size is dependent upon the size and type of the installation. For private use, where perhaps a *dozen negatives* require to be developed at a time, a capacity of *20 ounces* (500 c.cm.) for sizes up to $2\frac{1}{4} \times 2\frac{1}{4}$ (6×9 cm.), or *40 ounces* (1 litre) for sizes up to $\frac{1}{4}$ plate (9×12 cm.) will suffice.

The actual routine of development is as follows:

The plates or films are loaded into *holders* which grip them reasonably firmly and prevent touching or movement and facilitate quick handling.

The holders or frames are then lowered into the tank, and given *one or two sharp up and down movements* to displace any air-bubbles which may have formed on the sensitive surfaces.

The negatives must not be left motionless in the developer the whole of the time. To do so would be to run the risk of various troubles developing as we have already seen. In particular we risk the local concentration of *bromide* and the consequent weakening of development at those points. A common effect caused in this way is the appearance of *light streaks* down the negative. These owe their origin to the downward flow of bromide rich solution, which is heavier than the normal developer solution and so moves toward the bottom of the tank. Wherever it is in contact with the developing film it *slows down* development. This action is particularly strong in the neighbourhood of heavy densities in the negative. To obviate these defects the solution in the tank should be given a definite movement during development to ensure thorough mixing of the solution. In some cases *mechanical stirrers* are used for this purpose, but it can be achieved equally well by moving the holders or frames in such a manner as to give a stirring motion to the liquid. This should be done *at intervals of about a minute* while development is in progress.

ARRANGEMENT OF THE DARK-ROOM

The fact that the handling of sensitive photographic materials requires a dark room does not mean that any inconvenient corner should be chosen.

Not only should there be sufficient space to work in comfort, but ventilation should be good and the conditions such that even a prolonged spell in the dark-room should be possible without any inconvenience and certainly without any unhealthy influence. Photographic materials are just as sensitive to bad conditions, poor ventilation, damp, etc., as the human organism.

Darkening the Room

Darkening the room usually involves dealing with a window, and there is a fairly wide choice of methods. The important point is so to arrange matters that the window can easily be opened when required.

A very simple arrangement consists of a *wooden frame* which fits snugly into the window opening, the frame being filled with some opaque substance such as three-ply wood, thick cardboard or even opaque cloth. If the edges require sealing this can be done with *adhesive tape* (see page 120).

Where the window is fairly large, a very practical arrangement is one in which the opaque material takes the form of a *roller blind running in slits* at the side which form an effective light seal. Such frames, with blind complete, are obtainable from photographic dealers ready for fitting, but the handy-man can make one for himself without much trouble. The point to remember is that the slides at the side in which the blind runs must be deep enough to form a good light seal. They should be not less than *2 inches deep* and about *1/5th inch across*, and should be painted *matt black inside*. The spring roller blinds can be obtained easily and are built

into a partly-enclosed cover at the top of the frame (see page 120).

Walls and Floor

The old idea that the walls of a dark-room should be black or some very dark colour is now dead. Modern dark-rooms have *light-coloured walls* which allow of reasonable light in the room. Remember that the walls can only reflect the light which falls upon them, hence if that light is safe for photographic materials the light they reflect will also be safe.

The most serviceable colour for walls is a light *grey* or even a pure light *yellow*: the ceiling and, if desired, the upper part of the walls can be finished in *white*: this is particularly useful when indirect lighting of the dark-room is used (see page 114).

The lower part of the walls should be finished off with a *waterproof coat* which will allow of their being wiped down and cleaned with a damp cloth. The area of the wall behind the wet bench where developing and the like is carried out, also behind sinks where they occur should be specially protected against splashes, etc. This can be done either by applying a couple of coats of a good *oil paint* or by fixing *oilcloth* or "American cloth" in such areas. Where a really large volume of work is being done, thin sheet *lead* is very suitable.

Where rather dim light is much used, as when panchromatic negative material predominates, a useful tip is to paint the *corners and edges* of tanks, tables, cupboards and the like with *white*. This renders movement in the dark-room much easier and much more safe.

In a busy dark-room the *floor* calls for special consideration. It should be protected against moisture and chemical action. The best material is *asphalt*, or one of the special chemical resistant *concrete coatings*, but these are expensive and

cannot be laid everywhere. The next best is a good quality *linoleum* which is kept clean and well waxed. This can be underlaid with *bitumen paper* as an extra precaution against liquids getting through and damaging the actual floor.

Dark-Room Illumination

The adequate and comfortable handling of negative material in the dark-room is very largely dependent upon safe and proper dark-room lighting. Contrary to a widely-held opinion, this does not mean that a safely-lit dark-room is equivalent to a darkly-lit dark-room. A *correctly-lit dark-room can be relatively light* and actually safer than a room which is much darker but is illuminated with an inappropriate light.

Good practical dark-room lighting involves the right choice of safelight *filter* and the correct *light power* of the bulb or lamp to be used. The light must be of such quality and intensity that the sensitive material can be handled for the requisite time without any trace of fog appearing, and the illumination must be sufficient to permit of all the usual manipulation being carried out with ease and certainty.

The safety of the light depends on the colour of the safelight and the candlepower of the lamp behind it. The photographic manufacturer has taken the trouble to investigate all this and to make the necessary measurements and has prescribed the safelight and the strength of the light which can be used. For this reason the preparation of safelights or their improvisation by the photographer himself is unwise and definitely not recommended.

The choice of safelight will naturally depend upon the nature of the film or other negative material used. With *orthochromatic film* a *red safelight* is called for while *panchromatic materials*, if light is used at all, call for a *green light* of very low intensity.

Infra-red materials require a special safelight. *Infra-red*

emulsions are quite insensitive to a band in the green, but the safelight must be specially prepared so that it does not pass any infra-red. The firms which supply infra-red materials also supply safelights which completely fulfil all requirements; these will be found in Tables **XVII**, **XVIII** and **XIX**. On no account must the dark green safelight provided for pan materials be used as these pass considerable quantities of infra-red and will certainly fog infra-red plates or film. If you are using infra-red then you must use *special infra-red filters and special infra-red safelights*.

The disadvantage of using green light of very low intensity is compensated for by our eyes being particularly sensitive to green, and by allowing the eyes to become accustomed to the dim green light it will be found that work can be carried out quite comfortably after the first few minutes in the dark-room.

The actual lighting or illumination of the dark-room will depend upon whether it is a small room used only occasionally, or a fairly large room in which developing is being done fairly constantly. To some extent the nature of the materials will also play a part. Tables **XVII-XIX** indicate the various types of safelight and the strength of the lamp that should be used for the various types of sensitive material.

It will be seen that *direct and indirect illumination* are mentioned. For the small dark-room which is used occasionally direct lighting is sufficient, but for a dark-room where a good volume of work has to be done indirect lighting is far and away the best. This is obtained by a lamp of the type shown on page 119, so arranged that its light falls from above and is also reflected from the ceiling. This supplies well diffused and perfectly safe light which is easy and comfortable to work in. The *ceiling should not be too high*, and should have a light and smooth surface; if it is above 10 feet from the floor the lamp should be fitted with a reflector a foot or so above it.

XVII.—TABLE OF WRATTEN SAFELIGHTS

	DIRECT ILLUMINATION STANDARD WRATTEN	WRATTEN PYRAMID	INDIRECT ILLUMINATION KODAPAN	WRATTEN PYRAMID
Electric bulb to use	25 watt pearl in all cases			
Working distance	4 ft. from sensitive surface		6 ft. from reflecting surface	
FILMS AND PLATES	SAFELIGHT TO BE USED			
Lantern plates and slow non-colour sen- sitive Process materials	OA	OA	OO	OO
Slow and medium speed non-colour sen- sitive materials	1	1	0	0
Fast non-colour sen- sitive materials	2	2	1	1
Slow and medium orthochromatic materials	2	2	2	2
Fast orthochromatic materials	2B	2B	2	2
Slow panchromatic materials	3	3	5	5
Fast panchromatic materials	not recommended		3	3
All X-ray films	6B	6B	6BR	6BR
Infra-red sensitive materials	9	9	9	9

XVIII.—TABLE OF ILFORD SAFELIGHTS

" S " ...	...	A brown safelight for use with lantern plates, bromide and gaslight papers.
" F " ...	...	Dark brown for fast non-colour sensitive materials.
" X " ...	...	Olive green for X-ray films and X-ray papers only.
" Iso " ...	...	Red: for all orthochromatic materials.
" G " ...	...	Dark green for panchromatic materials of medium speed.
" G.B." ...	...	Greenish blue for faster panchromatic materials.
Bright Green ...	...	Green: for desensitised panchromatic materials.
Infra-red ...	...	Yellow green: for infra-red materials only.

XIX.—TABLE OF AGFA SAFELIGHTS

No. 103. Green ...	...	For Agfacolor plates, panchromatic plates and films, and all desensitised, supersensitive plates and films.
No. 104. Deep Orange		For positive, ordinary process, and X-ray films and plates.
No. 107. Red....	...	For all orthochromatic plates and films.
No. 108. Green ...	...	For supersensitive panchromatic plates and films.

Ventilation

Every dark-room should be well ventilated, but the means used to that end will naturally depend upon its size and the volume of work done in it.

In large business establishments an installation is required both to provide fresh clean air and to exhaust the used air from the room.

In a room of normal size which is reasonably well ventilated, when in ordinary use, *two openings*, one at *ground level* and one at *ceiling level*, should provide adequate ventilation. Naturally they must be light tight, but this is not difficult to arrange. The overall size of the openings should be about 6×30 inches: the light traps are formed by thin boards providing a *double right angle channel* which will effectually prevent any direct beam of light penetrating and

each light trap must be painted matt black over the whole of the interior. The two wings of the light trap can be about 3 inches apart (see page 121).

Light-Tight Entrance

In the case of a busy dark-room where there is much movement of personnel, the entrance should be some form of light trap.

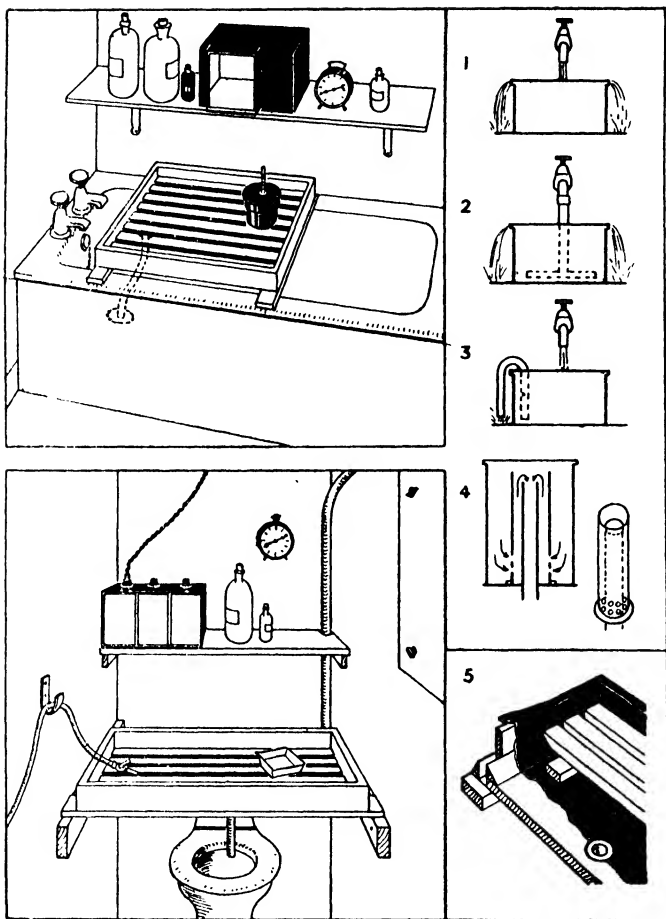
The simplest way is to build a light-tight space into which the door can open, in front of which is hung a heavy *light-tight curtain*. For large establishments an arrangement with *double doors* and more space between them is necessary, or the *light-tight labyrinth* may be used, which obviates the use of doors altogether (see page 119).

The Working Place

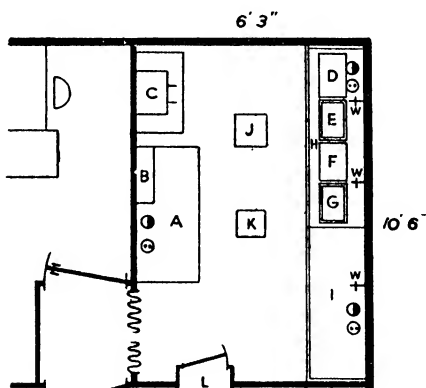
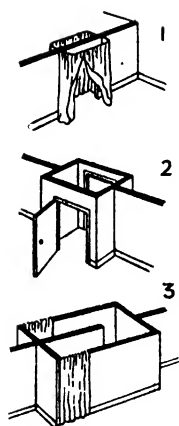
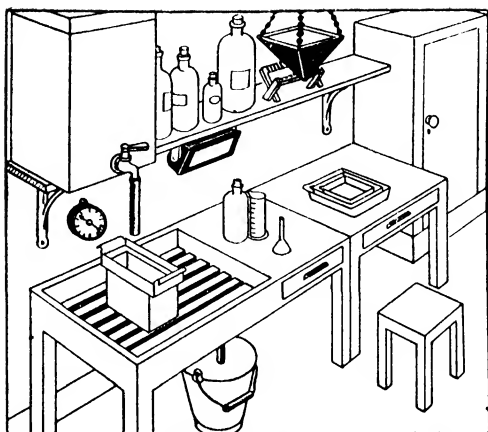
As the greater part of the work in a dark-room consists in handling solutions, an ordinary work bench is unsuitable, and in planning a dark-room, provision should be made for the necessary tanks or sinks to accommodate the various baths which are constantly in use.

In the small dark-room *stoneware sinks* can be used, but where a big volume of work has to be handled *lead-lined wood troughs* or sinks are preferable. The bottom of the sink should be provided with a *wooden rack* upon which tanks and dishes can rest, and which will allow of the free flow of liquid through the sink. As an extra precaution against wet floors, etc., the under-part of the tanks can be provided with a separate *draining board* (see page 121), which will catch all spilt or splashed liquor and convey it to the drain.

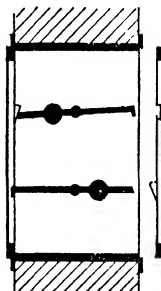
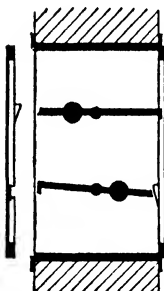
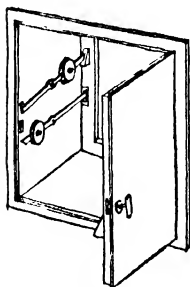
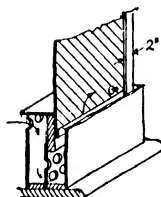
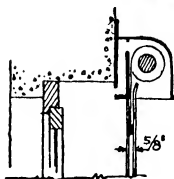
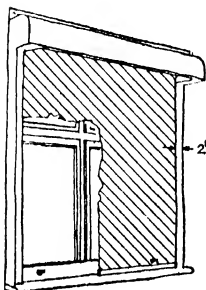
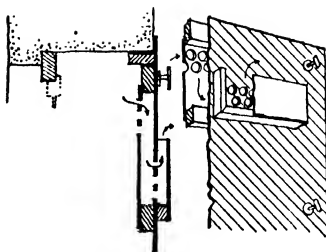
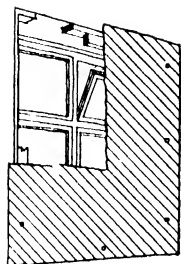
In large installations it is usual for the fixed films to be washed in a daylight or otherwise lit room; this involves the provision of a *light-tight trap* through which materials can be passed from the dark-room to the washing-room.



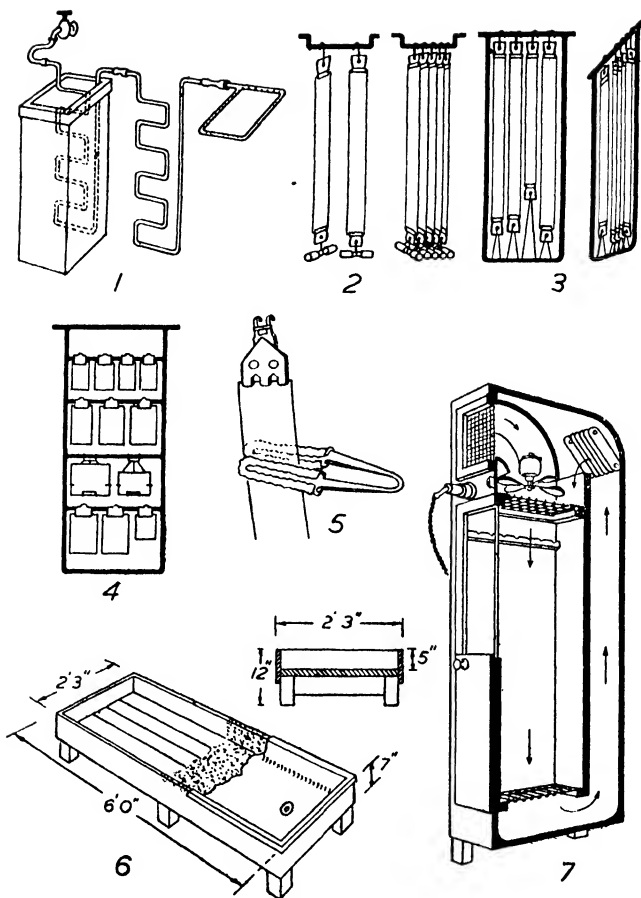
Left Top and Bottom: TWO IMPROVISED DARK-ROOMS
 Right, 1-4: METHODS OF WASHING. Right, 5: MAKING A
 WOODEN TANK OR SINK
 (See pages 123-124)



Right Top: DARK-ROOM WITHOUT RUNNING WATER.
 Right Bottom: GROUND PLAN OF LARGE DARK-ROOM.
 Left: ARRANGEMENTS FOR LIGHT-TIGHT ENTRANCE
 (See page 124)



Top and Centre : DARKENING WINDOWS AND VENTILATION.
 Bottom : LIGHT-TIGHT HATCH WITH SAFETY LOCKING DEVICE.
 (See pages 124-125)



1. COOLING SYSTEM FOR TANKS. 2. HANGERS FOR ROLL FILMS
 3. TENSION FRAMES FOR ROLL FILMS. 4. HANGERS FOR PLATES
 AND FLAT FILMS. 5. WIPING TONGS. 6. STANDS FOR TANKS.
 7. DRYING CUPBOARD
 (See pages 125-126).

Improvising a Dark-room

Such arrangements as have just been discussed are not for the amateur, who frequently must make the bathroom his dark-room. In such a case the best arrangement is to have a *wooden rack which fits on top of the bath* (see page 118). On this can be placed a large enamelled dish which can be supplied with water through a rubber tube from the tap.

Where a small room is available, then it can be arranged so that everything required in ordinary dark-room work is to hand (see page 119).

When possible, arrangements for *drying* as well as for *printing*, *enlarging*, etc., should be separated from that part of the room where developing and the like is carried out. This can sometimes be done in a simple manner by dividing the room into two by means of a light partition which allows one part to be used in daylight while the other remains the actual dark-room. In such a case only the apparatus which really belongs to the dark-room is kept there; all other operations, including the *washing* of materials if desired, are then carried out in the other room in which all after-treatment of the negative is done, including *reduction* or *intensification* if necessary (see page 119).

Page 118: IMPROVED DARK-ROOMS. The drawing shows a method of improvising a dark-room in a bathroom or even a lavatory. It consists in providing a wooden frame of such dimensions that it can rest on the sides of the bath, or on small supports if a lavatory has to be used. The frame supports either a metal tray or wooden dish which has a drain hole and a rubber tube to carry away waste. The bottom of the tray or dish has a wooden rack upon which dishes or tanks can rest. In the *upper drawing* a daylight developing tank is shown. In addition to the frame a shelf is provided upon which the necessary additional apparatus can rest, such as a dark-room clock, the safelight, measures, bottles, etc. In the *upper drawing* a simple dark-room lamp is shown, but *below* is one with three safelights, yellow, green and red, which are controlled from the switch at the side.

Page 118 (1-4): RIGHT AND WRONG METHODS OF WASHING. However washing is done it is essential to remove the used wash water which contains hypo. As a solution of hypo is heavier than water it sinks to the bottom of any vessel and remains there unless special measures are taken to remove it. In case 1 this is not achieved ; unless

the stream of water from the tap is very strong it simply overflows at the sides. The arrangement in 2 is better, where the water flows in at the bottom of the wash vessel; but 3 and 4 are better still, where the water is syphoned away and a strong flow of water takes place across the bottom of the vessel and sweeps the hypo laden water away. In 3 the syphon is fixed at the side of the tank, but in 4 it is built into it and is part of the outflow.

Page 118 (5): MAKING A WOODEN TANK OR SINK. The drawing shows how the sink shown on page 119, left, can be built in a simple manner using wood. The inside of the tank can be painted with bitumen paint, or lined with thin lead sheet.

Page 119 (Top): DARK-ROOM WITHOUT RUNNING WATER. Many a photographer has to make shift without running water. The drawing shows a good arrangement under such conditions. One-half the working bench or table is made in the form of a sink, which has a drain leading into a bucket. Here the sink, on a bracket, is a water tank. Lighting is by means of a wall dark-room lamp, seen under the shelf, and a ceiling lamp for indirect light from ceiling. The drying rack for plates is on the shelf and a small developing tank is in the sink. Dishes, measure, etc., are on the table.

Page 119 (Bottom): GROUND PLAN OF LARGE DARK-ROOM FOR BUSINESS PURPOSES. The main part of the plan shows the arrangement of the dark-room proper with door and light-tight vestibule communicating with the room on the left. A is the general work or sorting table with shelf B. C is the cupboard for the developing hangers, D the developing tank, E the rinsing tank between developing and fixing, F fixing tank and G the washing tank. I is a large sink in which dish development can be carried out. J and K are ceiling safelights and L is a light-tight hatch. Taps, wall safelights, etc., are indicated by easily understood symbols.

Page 119 (Left): ARRANGEMENTS FOR LIGHT-TIGHT ENTRANCE AND EXIT. (1) Door with heavy curtains hung either side of the door opening. (2) Small cubicle with double doors. (3) Labyrinth without doors, allowing free ingress and egress, with or without curtains; if the side passage can be made sufficiently long, curtains are not necessary.

Page 120 (Top): SIMPLE WINDOW SHUTTER OF PLY-WOOD. A wooden frame is fitted to the window and the sheet of ply-wood screwed to it as shown in top left-hand diagram. Ventilation can be assured, as seen in the top centre sketch, by means of a row of holes cut in the ply-wood, over which is arranged a small light-lock, the details of which are indicated in the top middle and right-hand sketches. The holes in the main sheet of ply-wood are protected on the inside by the box-like structure with opening at the top, while on the outer side another similar structure carries a row of holes situated some inches above those in the main sheet of ply-wood, thus providing a light-lock which allows free access of air but prevents any light entering.

Page 120 (Middle): DARKENING BY ROLLER BLINDS. These

fittings can usually be obtained from any reputable dealer. The blind runs in slots at either side of the window which provide efficient light-traps. If desired a ventilating trap can be arranged at the bottom of the blind as shown in the sketch on the *right-hand* side. The arrangement is similar to that described above, and can be at the side or across the whole width of the window as desired.

Page 120 (Bottom): LIGHT-TIGHT HATCH WITH SAFETY LOCKING DEVICE. The details can be seen from the three sketches. Two iron levers, each with a weight which normally keeps them in the locked condition, are fitted to the side wall of the hatch. Each door has a countersunk catch into which one end of the levers can fall and also a small ramp set opposite the other lever which prevents it locking so long as the door is open. As soon as one door is opened, thus removing the ramp, the corresponding lever falls by virtue of the weight and so automatically locks the opposite door. When the open door is closed the ramp again comes into action, raising the lever and so releasing the opposite door.

Page 121: ARRANGEMENT OF LARGE DARK-ROOM FOR BUSINESS PURPOSES. As the perspective drawing shows, the space is divided into two rooms. On the left the developing and fixing is carried out, while on the right the washing is done. Communication between the rooms is by means of a hatch. The tanks in both rooms are raised from the floor and so guarded that spots, splashes or drops of fluid can drain away and not collect on or damage the floor. As the illustration shows, a slightly raised gallery is provided which in fact is a long, shallow tank or sink, in which is placed the wooden rack *D* which acts as foot walk and support for the tanks *1, 1, 2*, etc. The sink or channel *B* is provided with a drain *C* and a pipe leading to the outside drains. In the room on the left are three developing tanks, *1, 1, 1*, a rinsing tank *2* and the fixing tanks *3*. These last are built into the wall *H*, so that they project into the room on the right and are provided with light-tight lids. This allows of the fixed films being taken out, with their holders *7*, in the well-lit room on the right without interfering with the operations in the dark-room. After they are taken from the fixing tanks they are washed in the washing tanks *4, 4, 4*. In the dark-room light is obtained from the wall dark-room lamps *6*, of which a sufficient number are installed to provide safe but adequate lighting; in the room on the right, wall lamps can be installed but safelights are not necessary. The tanks are provided with taps *E* at the base, running into the underlying sink so that they can be emptied as required. Ventilating spaces are provided in the wall *H* just below the ceiling *G* with the necessary light-traps *F*, and others at floor level to ensure plenty of fresh air.

Page 122 (1): COOLING SYSTEM FOR DEVELOPER AND FIXING TANK. The importance of temperature and its effects in development, see page 83, are such that every attempt should be made to ensure that a temperature of 65°F. (18°C.) is not widely departed from. To this end the simple arrangement shown here can help either in cooling

in hot, or in warming in cold, weather. The piping may be of any suitable material such as glass tubing which is easily bent into the required form. When used for cooling the water can be used in the washing tank. Connections are by flexible rubber tubing.

Page 122 (2): HANGERS FOR ROLL FILMS. The films are secured to the hanger by clips of suitable metal, monel metal, pure nickel, or stainless steel being the best ; the hanger rests on the walls of the tank ; at the bottom of the film a weight is attached to prevent curling of the film. When using such hangers the films should not be loaded too closely together in the tanks.

Page 122 (3): TENSION FRAMES FOR ROLL FILMS. This method of developing films is preferable to the previous in that although more time is required to load the frame, there is greater security in handling the films and less likelihood of damage through abrasion.

Page 122 (4): HANGERS FOR PLATES AND FLAT FILMS. Here the flat films are secured by clips while the plates are held in wire cradles.

Page 122 (5): WIPING TONGS. A valuable accessory in the dark-room where many roll films are developed. The fingers of the tongs are covered with viscose sponge and provide an easy and safe method of wiping off superfluous moisture from films before placing them in the drying cupboard.

Page 122 (6): STANDS FOR TANKS. Stands of varying shape and size for raising tanks from the floor can be built, as shown in the diagram, of wood and lined with bitumen paper.

Page 122 (7): DRYING CUPBOARD. The quick and certain drying of negative materials calls for warmed air in constant circulation and a good supply of fresh air. The diagram illustrates a drying cupboard in which the air is heated by an electric heating element and circulated by a ventilator and baffles with a small electric fan.

DEVELOPER FORMULAE

There are so many developer formulae that it is no easy matter to survey them clearly or to reduce the host of recipes and processes to a definite order. If we desire to do so, we shall have to separate them into particular groups; this involves choosing the principle upon which they are to be so separated, a matter of no little difficulty. An obvious method would be to take the developer substance as the deciding factor, but one and the same developing agent can serve various purposes. The most practical method would appear to be a division according to their mode of application and that we shall follow.

NORMAL DISH DEVELOPERS

The term "normal" is not intended to convey any special characterisation, rather is it chosen to distinguish the formulae gathered under this heading from all those other developers which have special properties. In the "normal" group will be included all formulae for *general use* which are *not* characterised by having some special influence on the *grain* of the developed image, nor on the *colour* of that image, neither do they affect the usual development process.

Metol

Important characteristic: Soft and rapid working.

I.—SINGLE-SOLUTION CONCENTRATED METOL DEVELOPER

Metol	...	...	...	...	300 grains	15 grams
Sodium sulphite, anhyd.	...	...	...	...	3 ounces	75 grams
Potassium carbonate	...	...	...	...	3 ounces	75 grams
Potassium bromide	...	...	...	...	40 grains	2 grams
Water to make	...	...	...	...	40 ounces	1,000 c.cm.

For use, dilute 1 part with 4 parts water. Development time 3–5 minutes.

For tank development dilute with 10 parts water. Time 20 minutes.

2.—TWO-SOLUTION METOL DEVELOPER

A.	Metol	...	...	...	200 grains	10 grams
	Sodium sulphite, anhyd.	...	...	...	2 ounces	50 grams
	Water to make	...	...	...	40 ounces	1,000 c.cm.
B.	Sodium carbonate, anhyd.	...	...	...	1½ ounces	35 grams
	Potassium bromide	...	...	...	20 grains	1 gram
	Water to make	...	...	...	40 ounces	1,000 c.cm.

For use mix an equal volume of A and B.

If a more rapid and stronger working developer is desired, increase the proportion of B.

Hydroquinone

Important characteristics: Slow and contrasty working. Very sensitive to low temperature, very inactive below 60°F. (15°C.).

3.—SINGLE-SOLUTION HYDROQUINONE DEVELOPER

Hydroquinone	...	...	...	1½ ounces	33 grams
Sodium sulphite, anhyd.	...	...	...	4 ounces	100 grams
Potassium carbonate	...	...	...	1 pound	400 grams
Potassium bromide	...	...	...	10 grains	0.5 grams
Water to make	...	...	...	40 ounces	1,000 c.cm.

Dilute with 4 to 6 parts water. Development time 5–7 minutes.

4.—TWO-SOLUTION HYDROQUINONE DEVELOPER

	Hydroquinone	1 ounce	25 grams
	Sodium sulphite, anhyd	4 ounces	100 grams
	Water to make	40 ounces	1,000 c.cm.
B.	Potassium carbonate	2 ounces	50 grams
	Water to make	40 ounces	1,000 c.cm.

For use take 4 parts of A to 20 parts of B. Development time 5–7 minutes.

If a more contrasty and more rapid developer is required, increase the proportion of B.

Metol-Hydroquinone

Important characteristics : Useful combination of the properties of both developing agents. Of universal application.

5.—SINGLE-SOLUTION METOL-HYDROQUINONE DEVELOPER

Metol	...	...	...	...	100 grains	5 grams
Hydroquinone	...	...	...	...	140 grains	7 grams
Sodium sulphite, anhyd.	...	...	...	...	2 ounces	50 grams
Potassium carbonate	...	...	...	...	4 ounces	100 grams
Potassium bromide	...	...	...	...	50 grains	2.5 grams
Water to make	...	...	...	...	40 ounces	1,000 c.cm.

For use dilute one volume with 3–4 parts water. Development time *5 minutes*.

6.—TWO-SOLUTION METOL-HYDROQUINONE DEVELOPER

A.	Metol	...	...	...	...	100 grains	5 grams
	Hydroquinone	...	...	...	...	140 grains	7 grams
	Sodium sulphite, anhyd.	...	...	...	...	2 ounces	50 grams
	Potassium bromide	...	...	...	...	50 grains	2.5 grams
	Water to make	...	...	...	...	60 ounces	1,500 c.cm.
B.	Potassium carbonate	...	...	...	...	4 ounces	100 grams
	Water to make	...	...	...	...	20 ounces	500 c.cm.

For use take 3 parts A, 1 part B and 4–6 parts water. Development time *5 minutes*.

The less water and the more of solution B used, the more rapid will be the development and the more contrasty the result.

7.—FOCAL-UNIVERSAL M-Q DEVELOPER

Metol	...	...	...	...	...	60 grains	3 grams
Sodium sulphite, anhyd.	...	...	...	...	...	3 ounces	75 grams
Hydroquinone	...	...	...	...	...	220 grains	11 grams
Sodium carbonate, anhyd.	...	...	...	...	...	3 ounces	75 grams
Potassium bromide	...	...	...	...	...	20 grains	1 gram
Water to make	...	...	...	...	...	40 ounces	1,000 c.cm.

(1) At the above strength it is rapid working and contrasty and can be used for technical photography, X-ray films and process work where the highest contrast is not required. Development time *3–5 minutes*.

(2) For dish development of plates and films dilute according to the contrast required with from three to seven volumes of water. The more concentrated the developer the higher the contrast and more rapid the development. With a dilution of 1 part stock solution to 5 parts water, development time is 5-7 minutes.

(3) For tank development, including daylight developing tanks take one part stock solution to 10-15 parts water. Development time 10-15 minutes.

(4) For gaslight papers dilute one volume with two volumes water. Development time 45-60 seconds.

(5) For bromide prints and enlargements. One part stock solution to 5-7 parts water. Development time $1\frac{1}{2}$ -2 minutes.

Chlorquinol

Important characteristics: Similar in properties to hydroquinone but more rapid working.

8.—SINGLE-SOLUTION CHLORQUINOL DEVELOPER

Chlorquinol	...	...	...	2 ounces	50 grams
Sodium sulphite, anhyd.	...	...	...	4 ounces	100 grams
Potassium carbonate	...	...	...	12 ounces	300 grams
Potassium bromide	...	...	...	100 grains	5 grams
Water to make	...	...	...	40 ounces	1,000 c.cm.

For use take 1 part of solution and 3-5 parts water. Development time 5-7 minutes.

9.—TWO-SOLUTION CHLORQUINOL DEVELOPER

A. Chlorquinol	...	...	...	1 ounce	25 grams
Sodium sulphite, anhyd.	...	...	...	4 ounces	100 grams
Water to make	...	...	...	60 ounces	1,500 c.cm.
B. Sodium carbonate, anhyd.	...	...	...	4½ ounces	120 grams
Potassium bromide	...	...	...	50 grains	2.5 grams
Water to make	...	...	...	40 ounces	1,000 c.cm.

For use take 30 parts A to 20 parts B. Development time 5-7 minutes.

If a somewhat softer working developer is desired, then add 20-30 parts of water.

Metol-Chlorquinol

Important characteristics: Similar properties to metol-hydroquinone.

10.—METOL-CHLORQUINOL DEVELOPER

Metol	...	...	...	...	160 grains	8 grams
Chlorquinol	...	...	...	...	2 ounces	50 grams
Sodium sulphite, anhyd.	...	...	...	...	4 ounces	100 grams
Potassium carbonate	...	...	...	...	10 ounces	250 grams
Potassium bromide	...	...	...	...	40 grains	2 grams
Water to make	...	...	...	...	40 ounces	1,000 c.cm.

For normal development, *5 minutes*, use 10 parts water to 1 part solution.

For rapid development, *2–3 minutes*, take 1 part solution to 5 parts water.

Caution: The metol and the chlorquinol must be completely dissolved before the sulphite is added to the solution.

Pyrocatechin

Important characteristics: Similar properties to hydroquinone. Special applications see page 160.

11.—SINGLE-SOLUTION PYROCATECHIN DEVELOPER

Pyrocatechin	...	...	...	...	$\frac{3}{4}$ ounce	20 grams
Sodium sulphite, anhyd.	...	...	...	...	2 ounces	50 grams
Caustic soda	...	...	...	...	320 grains	16 grams
Potassium bromide	...	...	...	...	40 grains	2 grams
Water to make	...	...	...	...	16 ounces	400 c.cm.

To use, dilute 1 part with 10–15 parts of water. Development time *5 minutes*.

Caution: The pyrocatechin must be dissolved only when *all* the other constituents are in complete solution. Does not keep well; should be made up immediately before use.

12.—TWO-SOLUTION PYROCATECHIN DEVELOPER

A. Pyrocatechin	...	...	...	...	200 grains	10 grams
Sodium sulphite, anhyd.	...	...	...	...	$\frac{1}{2}$ ounce	20 grams
Water to make	...	...	...	...	20 ounces	500 grams
B. Potassium carbonate	...	...	...	...	2½ ounces	60 grams
Water to make	...	...	...	...	20 ounces	500 c.cm.

Caution: Dissolve the pyrocatechin when the sulphite is dissolved.

For use take equal volumes of A and B. Development time 7 minutes.

Pyrogallol

Important characteristics: Gives negatives with delicate gradation and good detail. Owing to the ease with which pyro is oxidised in alkaline solution, single-solution developers are impracticable as in this form their keeping properties are very poor.

13.—TWO-SOLUTION PYRO DEVELOPER

A. Pyrogallol	...	...	2 ounces	50 grams
Potassium metabisulphite	...	...	2 ounces	50 grams
Sodium sulphite, anhyd.	...	...	5 ounces	125 grams
Water to make	...	...	40 ounces	1,000 c.cm.
B. Sodium carbonate, anhyd.	...	...	3 ounces	75 grams
Water to make	...	...	40 ounces	1,000 c.cm.

For use take 1 part A, 1 part B and 4 parts water. Development time 6–7 minutes.

Glycin

Important characteristic: Slow and clean working.

A concentrated developer with good keeping properties is that first suggested by *Hubl* which appears like a thin broth.

14.—SINGLE-SOLUTION GLYCIN DEVELOPER

1 ounce (25 grams) of anhydrous sodium sulphite is dissolved in warm water. Then add $\frac{1}{2}$ ounce (20 grams) glycin, followed immediately by 4 ounces (100 grams) of potassium carbonate. When cool there should be 6 fluid ounces (150 c.cm.) of a thin broth. If the volume is less than 6 ounces (150 c.cm.) it should be made up to that volume.

Before the broth is used it must be well shaken. Dilute 1 volume of the broth with 15 parts of water. Development time 8–10 minutes.

For tank development dilute 1 volume of broth with 50 parts of water. Development time 45–60 minutes.

15.—LESS CONCENTRATED GLYCIN STOCK SOLUTION

Glycin	...	...	...	...	2 ounces	50 grams
Sodium sulphite, anhyd.	...	...	...	...	4 ounces	100 grams
Potassium carbonate	...	...	...	...	10 ounces	250 grams
Water to make	...	...	...	...	40 ounces	1,000 c.cm.

For use take 1 part with 3-5 parts water. Development time 8-10 minutes.

For tank development, 1 part with 15 parts water. Development time 20 minutes.

16.—TWO-SOLUTION GLYCIN DEVELOPER

A. Glycin	...	...	...	...	$\frac{3}{4}$ ounce	20 grams
Sodium sulphite, anhyd.	...	...	...	...	2 ounces	50 grams
Water to make	...	...	...	...	40 ounces	1,000 c.cm.
B. Potassium carbonate	...	...	...	...	4 ounces	100 grams
Water to make	...	...	...	...	20 ounces	500 c.cm.

For use for normal contrast take 2 parts A, 1 part B, water 2 parts.

For soft working take equal parts A and B and 3 parts water.

For strong contrast take equal parts A and B and 1 part water.

Development time 8-10 minutes.

Para-aminophenol hydrochloride

Important characteristics : Rapid fog-free developer, not much affected by variations of temperature. Permits of preparation of concentrated stock solution.

17.—SINGLE-SOLUTION PARA-AMINOPHENOL DEVELOPER

Para-aminophenol hydrochloride	...	200 grains	10 grams
Potassium metabisulphite	...	$1\frac{1}{2}$ ounces	30 grams
Water up to	...	4 ounces	100 c.cm.

To this solution, with continuous shaking there is added little by little a 50 per cent solution of caustic potash until a precipitate which forms is just re-dissolved.

For use for normal contrast, 1 part stock solution to 20-25 parts water. Average development time 4-5 minutes.

For stronger contrast take 1 part solution to 10 parts water.

Caution: Note that heat will be generated in making the 50 per cent solution of caustic, and the solution must be cooled before adding it to the rest of the developer.

18.—TWO-SOLUTION PARA-AMINOPHENOL DEVELOPER

A. Para-aminophenol hydrochloride	...	1 ounce	25 grams
Water to make	...	40 ounces	1,000 c.cm.
B. Sodium sulphite, anhyd.	...	3 ounces	75 grams
Potassium carbonate	...	6 ounces	150 grams
Water to make	...	80 ounces	2,000 c.cm.

For use take 1 part A and 2 parts B. Development time 5–6 minutes.

19.—PARA-AMINOPHENOL-HYDROQUINONE DEVELOPER

Kodolon (Para-aminophenol oxalate)	30 grains	1.5 grams
Hydroquinone	40 grains	2 grams
Sodium sulphite	2 ounces	50 grams
Caustic soda	60 grains	3 grams
Potassium bromide	50 grains	2.5 grams
Water to make	40 ounces	1,000 c.cm.

Caution: Dissolve the *caustic soda* separately in a small quantity of water, then add the solution containing the other constituents already dissolved.

Development time 12–15 minutes.

20.—PARA-AMINOPHENOL-HYDROQUINONE REPLENISHER

Kodolon	160 grains	8 grams
Hydroquinone	60 grains	3 grams
Caustic soda	140 grains	7 grams
Sodium sulphite	2 ounces	50 grams
Water to make	40 ounces	1,000 c.cm.

Important characteristics : This developer has similar properties to a *metol-hydroquinone* tank developer, it does not keep quite so well and is perhaps not so energetic but its particular value lies in its usefulness in all cases where protection against metol poisoning is essential (p. 75).

Amidol

Important characteristic: Provides a rapid alkali-free developer.

21.—AMIDOL STOCK SOLUTION

Sodium sulphite, anhyd. ...	...	1 ounce	25 grams
Water to make ...	...	40 ounces	1,000 c.cm.

To 4 ounces of this solution (100 c.cm.) 10 grains (0.5 gram) of amidol is added just before use.

Development time 3–5 minutes.

Caution: The developer does not keep and should be discarded after use.

Examples of "Normal" Dish Developer Brands

Agfa—Rodinal, — M.Q. Developer, — Metol, — Glycin, — Hydroquinone, — Pyrogallol, — Portrait-Film Developer.
Burroughs Wellcome—"Tabloid", — Rytol, — Metol-Quinol, — Pyro-Metol, — Pyro-Soda, — Amidol, — Hydroquinone, — Metol.
Fink-Roselleve—Quinolin Universal Developer.
Gevaert—M.Q. Packet Developer, — Studio Film Developer.
Ilford—M.Q. ID2, — Certinal.
Johnson—Azol, — Amidol Packed Developer, — M.Q. Developer, — "One Solution" Developer, — "Scaloid" (Compressed Tablets): Glycin, Hydroquinone, Metol Quinol, Metol, Pyro-Metol, Pyro-Soda, Vedol.
Kodak—D61a Negative Developer Powder and Replenisher Powder — Press Contrast Developer, — D163 Special Developer Powder or Solution, — D177 Pyro-Soda Developer Powder, — DK 50 Developer Powder (M.Q. for portrait and commercial use), — Kodinol.
Marshall's Rodinal, — M.Q., — Universal Developer.
Perutz—M.Q. Developer, — Hydroquinone, — Perinal (Rodinal type).
Tetenal—TH Dev. (M.Q.), — Rapid Developer, — Universal.

NORMAL TANK DEVELOPERS

Tank developers intended to handle large numbers of plates or films must satisfy quite a number of conditions.

As development is by time and various negative materials develop at different rates, the developer must possess such properties that its results are neither too hard nor too soft.

As it is also in use for weeks or even months it must have good keeping properties and not be easily exhausted. These last-mentioned properties will naturally have their limits, depending in part on the extent to which the tank is used.

This also brings in another factor, that is the loss of

solution through usage. Every plate or film which passes through the tank removes a small quantity of solution which, in the aggregate, may amount to an appreciable volume. This loss must be made good and the volume of liquid in the tank maintained at or near its original level. This is done, not by the addition of water, but by using a solution of composition very similar to that of the original developer, which is called the *strengtheners* or the *replenisher*. This is added at suitable intervals, often first thing in the morning, and serves to maintain the level of the liquid in the tank and equally the energy of the developer.

Important characteristics : see above.

22.—TANK DEVELOPER

Metol	...	...	...	...	1 ounce	12.5 grams
Hydroquinone	...	...	...	...	$\frac{1}{4}$ ounce	20 grams
Sodium sulphite, anhyd.	...	...	...	...	6 ounces	150 grams
Sodium carbonate, anhyd.	...	...	...	...	3 ounces	75 grams
Potassium bromide	...	...	...	...	200 grains	10 grams
Water up to	...	...	...	...	2½ gallons	10 litres

Development time *10-12 minutes.*

For strengthener solution dissolve the same quantity of chemicals in half the quantity of water, omitting the bromide.

23.—KODAK D75 TANK DEVELOPER

A. Water at 125°F. (52°C.)	...	...	1 gallon	4.5 litres
Metol. (Elon)	...	...	1½ ounces	30 grams
B. Water at 125°F. (52°C.)	...	...	1 gallon	4.5 litres
Sodium sulphite cryst.	...	...	1 pound	500 grams
Sodium bisulphite	...	...	15 ounces	480 grams
C. Water at 125°F. (52°C.)	...	...	1 gallon	4.5 litres
Sodium sulphite cryst.	...	...	14 ounces	460 grams
Hydroquinone	...	...	5 ounces	125 grams
Pyro.	...	...	1½ ounces	30 grams
D. Water at 125°F. (52°C.)	...	...	1 gallon	4.5 litres
Sodium carbonate cryst.	...	...	5 pounds	2,250 grams

To make up 10 gallons (45 litres) of solution, 2 gallons (9 litres) of water are placed in the tank. The above four solutions are prepared separately, solutions A, B and C are added to the water in the tank in that order. Solution D

is cooled and then added and the total volume made up to 10 gallons (45 litres).

Time of development at 68°F. (20°C.) is 10 minutes.

Caution: The temperature of the tank should be kept at 68°F. (20°C.) and should not be allowed to fall below 65°F. (18°C.) nor to rise above 70°F. (21°C.).

24.—KODAK D75R. REPLENISHER SOLUTION

Water at 125°F. (52°C.)	...	...	1 gallon	4.5 litres
Metol, Elon	...	...	1½ ounces	30 grams
Sodium sulphite cryst.	...	...	15 ounces	480 grams
Sodium bisulphite	...	...	7½ ounces	240 grams
Hydroquinone	...	...	2½ ounces	62 grams
Sodium carbonate cryst.	...	...	3½ pounds	1,500 grams
Water to make	...	...	2 gallons	9 litres

When replenishing the tank a portion of the replenishing solution is mixed with an equal volume of water.

25.—AGFA No. 45 TANK DEVELOPER

Sodium sulphite, anhyd.	...	...	2 pounds	900 grams
Metol	...	...	3 ounces	75 grams
Hydroquinone	...	...	5 ounces	125 grams
Sodium carbonate, anhyd.	...	...	¾ pound	320 grams
Potassium bromide	...	...	1½ ounces	45 grams
Water	...	...	16 gallons	70 litres

Time of development 10–12 minutes.

26. FOCAL TANK DEVELOPER

Water at 125°F. (52°C.)	...	...	30 ounces	750 c.cm.
Metol	...	...	20 grains	1 gram
Sodium sulphite, anhyd.	...	...	¾ ounce	18 grams
Hydroquinone	...	...	40 grains	2 grams
Sodium carbonate, anhyd.	...	...	¼ ounce	6 grams
Potassium bromide	...	...	40 grains	2 grams
Cold water to make	...	...	40 ounces	1,000 c.cm.

27.—FOCAL TANK REPLENISHER SOLUTION

Water at 125°F. (52°C.)	...	...	30 ounces	750 c.cm.
Metol	...	...	40 grains	2 grams
Sodium sulphite, anhyd.	...	...	1¼ ounces	32 grams
Hydroquinone	...	...	80 grains	4 grams
Sodium carbonate, anhyd.	...	...	½ ounce	12 grams
Cold water to make	...	...	40 ounces	1,000 c.cm.

Important characteristics: The above formula supplies a

brilliant working, cheap and long-lived developer for all tank work and is specially suitable for *D* and *P* departments. The level of the developer in the tank should be maintained by the addition of replenisher as required.

Time of development 12 minutes at 65°F. (18°C.).

Examples of Normal Tank Developer Brands

Agfa—47 Developer.
 Ilford—P.M.Q. Developer, — M.Q. Developer.
 Johnson—Constant Endura, — Speedy, — Standard.
 Kodak—Time Standard Developer Powder, — Brownie Tank Powders — 3½" Tank Powders.
 P.A.C.—Tankronol.
 Tetenal—Medional, — Neotenal.

CONTRAST DEVELOPERS

Contrast developers are needed not only for special purposes (such as process work) but in many cases for general commercial work as well, particularly in Industrial and press photography.

There is, however, a basic difference between these two applications of contrast developers. While for process work the highest possible contrast is required, one has to choose for commercial work contrast developers which still give a good reproduction of half-tones.

Highest contrast is obtained with a caustic hydroquinone developer (e.g. No. 28). Developers of this type have, however, the disadvantage that the mixed working solution does not keep. We are, therefore, recording an alternative formula (No. 29) which has much better keeping properties but the contrast is a little less than that obtainable with No. 28. Both these developers are more contrasty than formula No. 30 which is, therefore, more suitable for commercial work.

28.—KODAK D153 HYDROQUINONE CAUSTIC POTASH

A. Hydroquinone	...	...	...	2 ounces	25 grams
Potassium metabisulphite	...	...	...	2 ounces	25 grams
Potassium bromide	...	...	...	2 ounces	25 grams
Water to make	...	...	...	80 ounces	1,000 c.cm.
B. Caustic Potash	...	...	...	4 ounces	50 grams
Water to make	...	...	...	80 ounces	1,000 c.cm.

Dissolve the chemicals in the order given. Use equal parts of A and B. Development time 2 minutes at 65 degrees F. (18 degrees C.)

29.—KODAK D154 SINGLE-SOLUTION CONTRAST DEVELOPER

Metol	...	...	...	45 grains	1.25 grams
Sodium sulphite anhyd.	...	...	1 ounce	350 grains	22.5 grams
Hydroquinone	...	...	...	210 grains	6 grams
Sodium carbonate anhyd.	...	...	2 ounces	175 grains	30 grams
Potassium bromide	...	...	...	18 grains	0.5 grams
Water to make	...	...	...	80 ounces	1,000 c.cm.

Dissolve the chemicals in the order given. Use without dilution. Development time 2-3 minutes.

Developer No. 29 gives higher contrast than the following developer.

30.—M-Q CONTRAST DEVELOPER

Water at 125°F. (52°C.)	...	...	...	64 ounces	2,000 c.cm.
Metol	...	...	...	128 grains	8.8 grams
Sodium sulphite, anhyd.	...	...	...	12½ ounces	384 grams
Hydroquinone	...	...	...	1½ ounces	35 grams
Sodium carbonate, anhyd.	...	...	...	6½ ounces	190 grams
Potassium bromide	...	...	...	360 grains	20 grams
Cold water to make	...	...	...	128 ounces	4,000 c.cm.

This solution is ready for use. Development time 5 minutes.

Examples of Contrast Tank Developer Brands

Kodak—D8 Maximum Contrast Developer Powder, — D19 and Developer Powder and Replenisher Powder, — D154 Kodakline Developer Powder.

Agfa—Printron Developer, — Reprolith Developer.

Johnson—Contrast Developer.

FINE-GRAIN DEVELOPERS

In no branch of photography have so many formulae been put forward as in fine-grain development, and this interest and activity is explained by the great importance which fine-grain development has for modern miniature films. It must, however, be said that out of the very large number of

formulae published the majority are only variations on a few original types, and very few indeed possess any special properties.

All fine-grain developers can be divided into two fundamental types, namely:

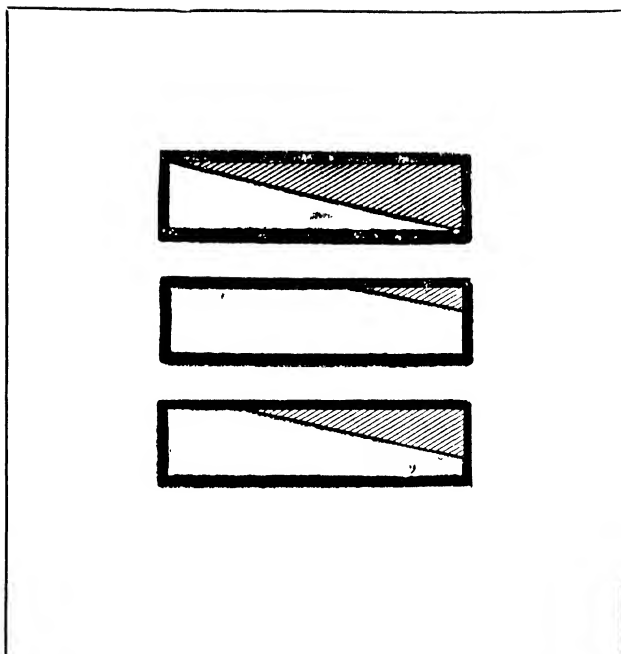
- (1) the *retarded* developer type,
- (2) the *true* fine-grain developer, often designated Super or Ultra-fine grain developer.

Retarded Under-Development

The principle by which the first type, i.e., the retarded developer, works is essentially a form of *retarded under-development*. Much the same result could be obtained with a normal rapid developer on a correctly exposed negative if the development time were rigorously cut down, but such a method is never given practical consideration because it would obviously sacrifice all the advantage gained by using a highly sensitive negative material.

The fine-grain developer allows us to obtain a better developed negative without the grain being unduly large. The fact that development is retarded has its *effect upon the contrast* of the negative, which becomes somewhat low in contrast, and this occurs equally with the second type of fine-grain developers. This emphasises the importance of developing modern negative material to a definite density or gamma, as only by so doing can one ensure that they will have good enlarging properties.

Whether a fine-grain developer belongs to the first or second type, it always leads to an apparent *loss of sensitivity*, best expressed perhaps as lower effective emulsion speed, and means have to be used to meet this. Generally speaking, this involves giving a *rather full exposure when developers of type 1 are to be used, and giving double the correct exposure where type 2 developers are to be employed*. As might be expected, this means that the correct exposure should be



DEVELOPER AND GRADATION

The three drawings here show a diagrammatic cross-section through the silver deposit in a developed emulsion. A normal developer, which gives a hard and dense image with full development (*top*) can give a softer contrast if it is allowed to act for a shorter time (*centre*). This leads, however, to a loss of sensitivity, and the gradation scale is often too short. A fine-grain developer, however, corrects this shortness of gradation by its compensating action, though it, too, develops lightly in the shadows and thus needs an increased camera exposure (*bottom*).

known with reasonable accuracy and it may be emphasised that when using modern miniature camera sensitive materials, accurate determination of exposure is essential.

The question as to which factor has the more important influence in fine-grain development has received a large amount of attention in recent times and much research and discussion. Out of the many theories and conjectures the following two conclusions are generally admitted to be well founded.

The first condition which a fine-grain developer must fulfil is that it shall be *capable of dissolving the silver bromide* present in the emulsion.

The second condition is that its energy of development shall be low, so that it is *slow working* and can give a negative of *low contrast* and *medium density*.

These two characteristics are found in all true fine-grain developers.

A Solvent for Silver Bromide

If in any developer the *sodium sulphite* content is raised to near the saturation point, that is about 4 ounces (100 grams) of the *anhydrous salt* in 40 ounces (1 litre) of water, then that developer is a useful solvent for silver bromide.

That this property has a favourable influence on grain has led to the addition of other supposed or actual solvents of silver bromide such as *ammonium chloride* and *hypo*, although their true value as additions to a developer is somewhat problematic, as they can give rise to fog. *Potassium sulphocyanide* has also been used.

The favourable action of *paraphenylenediamine*, the classical fine-grain developer, has often been explained as being due to it not only acting as a developing substance but also as a solvent for silver bromide. In actual fact, we can obtain similarly favourable results with other developing agents if they are combined with suitable solvents for silver

bromide. This is a matter of great practical importance for paraphenylenediamine has a number of very unpleasant properties. It is poisonous, its powder has very strong dyeing properties, it stains fingers and photographic materials, and can cause damage by staining the bath brown.

Hence it is important to have a developer which has the good, without the bad properties of paraphenylenediamine. *Orthophenylenediamine* is such a substance, it has low developing energy, is a good solvent for silver bromide and can be used in combination with other developing agents, in particular with *metol*. It gives excellent fine grain, has good keeping properties, is not quickly exhausted and shows no tendency to fog or stain.

Low Developing Energy

The second characteristic of the fine-grain developer, namely low developer energy, is easily attained by having a very *low alkali content*. If one uses a formula which has much *sodium sulphite* and no alkali, then one has a reasonably good though somewhat slow working developer. (No. 31, page 145.) Here the fact that sodium sulphite has a faint alkaline reaction plays a part.

One can increase the rate of development by carefully *increasing the alkalinity* by the addition of a weak or mild alkali such as *borax* or *Kodalk* (see page 66), or by the addition of a very small proportion of *soda*. *Tribasic sodium phosphate* or *metaphosphate* can be used or compounds of an organic character such as *triethanolamine* (No. 37, page 145), and *acetone* (No. 39, page 145). Between all these various materials there is very little difference in their action on the grain so long as care is taken to ensure that the alkalinity is the same and therefore the energy of development is not altered.

Fine-Grain Developers with Metol-Hydroquinone

The best-known developers of this type are summarised in Table XX, page 145.

Important characteristics: It will be seen that all are characterised by high sulphite content and either low alkali content or the presence of a weak alkali. Certain other developers are included in this table which make use of other normal developing agents such as *glycin* and *pyrogallol*.

Wherever borax is used in any developer the *granular* or *crystallised borax* should be used, as these are more easily soluble than the powder form which has a tendency to float on the surface of the solution and is only very slowly dissolved.

In formula No. 32 for *Kodak D76*, the *borax* can be replaced by an equal weight of *Kodalk* (see page 66). If the proportion of *Kodalk* is increased, the developer becomes proportionately more energetic, whereas an increase in the borax addition does not produce a proportional effect and the energy of the developer is only affected to a minor degree. Remember that increase in developer energy is always at the cost of fine grain.

Kodak D76 lends itself excellently to tank development. If it is used in this way the following replenisher solution should be used.

40.—KODAK D76R. REPLENISHER

Metol	...	...	...	...	105 grains	3 grams
Sodium sulphite anhyd.	...	...	...	...	8 ounces	100 grams
Hydroquinone	...	...	...	...	266 grains	7.5 grams
Borax	...	...	...	1 ounce	261 grains	20 grams
Water to make	...	...	...	...	80 ounces	1,000 c.cm.

Use the replenisher without dilution and add to the tank to maintain the level of the solution.

The use of this replenisher gives the tank about five times its normal life. If *Kodalk* has been used in making up the tank, it should also be used in compounding the replenisher solution. The following are the times of *Kodak D76* tank development for equal contrast with varying quantities of borax and *Kodalk*.

XX.—NORMAL OR RETARDING FINE-GRAIN DEVELOPERS

Formula	31 ANDRESEN	32 KODAK D76	33 AGFA STRONG	34 AGFA WEAK	35 GEVAERT	36 SEYE- WETZ	37 N.N.	38 R. B. WILLCOCK	39 SEYE- WETZ
Metal ...	15	2	8	4½	2	10	2	0.4	—
Hydroquinone ...	—	5	—	—	3	1	—	—	—
Pyrogallol ...	—	—	—	—	—	—	10	—	7
Sodium sulphite, anhyd. ...	75	100	125	85	100	60	100	24	120
Borax ...	—	2	—	—	2	—	—	—	—
Sodium carbonate, anhyd. ...	—	—	12	1	—	4	—	12	—
Potassium bromide ...	0.2	—	1.5	0.5	—	1	—	—	1
Special additions ...	—	—	—	—	Resorcin 2	Sodium triphos- phate 2	Triethano- lamine 2	Acetone 4	—
Development time in minutes ...	20	15	8	15	8	12	—	—	30

The above quantities are to be taken as parts per thousand or grams per litre of water

<i>Borax</i> Per 1 Litre	<i>Time</i>	<i>Kodalk</i> Per 1½ Litre	<i>Time</i>
2½ grams	20 min.	2 grams	20 min.
10½ grams	15 min.	5 grams	10 min.
15 grams	12½ min.	10 grams	7½ min.
20 grams	10 min.	20 grams	5 min.

When a fine-grain negative with low contrast is required then one can make use of one of the formulae in Table **XX** by diluting with water. This affects the life of the developer ; it is preferable to make use of this buffered developer :

41.—KODAK D76d. BUFFERED BORAX DEVELOPER

Metol	...	...	...	...	70 grains	2 grams
Sodium sulphite anhyd.	...	...	...	...	8 ounces	100 grams
Hydroquinone	...	...	...	...	175 grains	5 grams
Borax	...	...	...	...	280 grains	8 grams
Boric acid	...	...	...	...	280 grains	8 grams
Water to make	...	...	...	...	80 ounces	1,000 c.cm.

Average development time *20 minutes*. With a ratio of equal parts of borax and boric acid as given above, the time of development is unchanged from that of *D76*, No. **32**. By Increasing the quantity of borax with a corresponding decrease in the boric content, the development time is decreased. By decreasing the borax and increasing the boric acid proportionately the development time is increased. Developers with a high concentration of boric acid have a shorter useful life and they are also more susceptible to the reaction products of development.

The following developer by *Bloch and Mitchell* is designed to give similar results.

42.—ILFORD ID44 FINE-GRAIN DEVELOPER

Metol	...	...	...	...	80 grains	4 grams
Paraminophenol hydrochloride	...	...	...	...	100 grains	5 grams
Sodium sulphite, anhyd.	...	...	...	...	5 ounces	125 grams
Salicylic acid	...	...	...	...	10 grains	0.5 gram
Borax	...	...	...	...	100 grains	5 grams
Glucose (Dextrose) powder	...	...	...	...	½ ounce	20 grams
Calgon	...	...	...	...	20 grains	1 gram
Water to make	...	...	...	...	40 ounces	1,000 c.cm.

Examples of Fine-Grain Ready-Made-up Developers of similar characteristics :

Agfa 17—Final. Argus AR 1. Aurotone Auro-Film Dev. Burroughs Wellcome Tabloid Fine Grain, Defender 6-D Borax. Kodak D76 and D76R. Edwal 12, Thermo Fine Grain Tube. Fink Roselieve G.D.X. Haynes Dialon. Johnson Fine-Grain Developer. Kemp Super-speed 500. Oxford Opco Concentrate. P.A.C. Degrainol. Perutz Fine Grain. Raygram Ray-Del. Stuart Fine Grain. Walden R.F.D.

Fine Grain Developers without Alkali

The function of hydroquinone in M.Q. Developers of low activity like the formulæ numbers **32**, **35**, and **36** has been questioned by various authors but it has been shown quite conclusively that the presence of hydroquinone does increase the degree of development especially for the longer times but that at low gamma values the effect is relatively slight.

R. W. Henn and J. I. Crabtree have shown that the effect of hydroquinone may be largely offset by increasing the Metol content. This combined with the fact that Metol will develop without other alkali present than the sodium sulphite allows of a simple formula of three ingredients only :—Metol, Sulphite, Water, just as No. **31**. For this reason the Kodak laboratories have investigated thoroughly this type of developer and recommend the following formula :

43.—KODAK D23 DEVELOPER

Water (about 125°F.)	...	...	...	30 ounces	750 c.cm.
Metol	...	...	...	130 grains	7.5 grams
Sodium sulphite (desicc.)	...	...	...	4 ounces	100 grams
Water to make	...	...	...	40 ounces	1,000 c.cms

The following development times are recommended :

Kodak Super XX	...	...	...	35 mm. 22 min. :	Roll film 16 min.
Kodak Plus X	...	...	...	35 mm. 16 min.	
Kodak Panatomic X	...	...	...	35 mm. 13 min. :	
Kodak Verichrome	...	...	...	Roll film 16 min.	

By looking up these Kodak films in Table I, page 37, conclusion can easily be drawn as to the development time for other films on the market. When processing without replenishment of the developer an increase in time of 10 per cent for each successive 80 sq. in. of film per litre is recommended. The developer should be discarded after 10 rolls per litre. Using a replenisher, solution DK-25R (page 156)

should be added at the rate of $\frac{1}{2}$ of an ounce (22 c.cm.) per every 80 sq. in. of film. The most constant results are obtained if it is added after each roll, when working with small films, or after each 40 rolls in a 10-gallon tank.

A white scum of calcium sulphite frequently occurs on films processed in developers with high sulphite contents and low alkalinity. This scum is, however, easily soluble in acid stop baths and in fresh acid fixing baths, especially if the film is well agitated.

Super-Fine Grain with Silver Bromide Solvents

Important characteristics: Of all the super-fine grain developers incorporating a silver bromide solvent, those containing *sulphocyanides* or *thiocyanates* are best.

The following results published by Kodak laboratories show that in comparison with developers containing paraphenylenediamine the developer with sulphocyanide gives equal fine grain, somewhat better effective emulsion speed, and requires a much shorter time of development to reach the same density.

XXI.—TIME OF DEVELOPMENT, SPEED AND GRAININESS

Developer			Time of development	Emulsion speed	Graininess
Kodak D76	...	...	15 minutes	100	20
Paraphenylenediamine	...	...	50 "	50	10
DK20	...	...	18 "	65	10

44.—KODAK DK20 DEVELOPER

Metol	...	...	...	175 grains	5 grams
Sodium sulphite anhyd.	...	...	...	8 ounces	100 grams
Kodalk	...	...	...	70 grains	2 grams
Potassium thiocyanate (sulphocyanide)	...	...	...	35 grains	1 gram
Potassium bromide	...	...	...	18 grains	0.5 grams
Water to make	...	...	...	80 ounces	1,000 c.cm.

Use without dilution. Average development time about 15 minutes at 65 degrees F. (18 degrees C.). The useful life of this developer can be increased 5 to 10 times by the use of DK20R replenisher.

45.—KODAK DK20R. REPLENISHER SOLUTION

Metol	...	...	...	265 grains	7.5 grams
Sodium sulphite anhyd.	...	...	...	8 ounces	100 grams
Kodalk	...	...	1 ounce	260 grains	20 grams
Potassium thiocyanate (sulphocyanide)	...	...	...	175 grains	5 grams
Potassium bromide...	...	...	...	35 grains	1 gram
Water to make	...	...	...	80 ounces	1,000 c.cm.

Add to the tank as necessary to maintain the volume constant. A given high-light density will be maintained throughout the developer life for a constant development time at a constant temperature, provided the volume of replenisher added is about 5 gallons per 1,000 rolls of film (80,000 square inches) processed.

46.—FOCAL SUPER-FINE GRAIN DEVELOPER

Water at 125°F. (52°C.)	...	...	...	30 ounces	750 c.cm.
Metol	...	...	...	60 grains	3 grams
Sodium sulphite, anhyd.	...	...	...	3½ ounces	90 grams
Borax, crystals	...	...	...	20 grains	1 gram
Sodium carbonate	...	...	...	20 grains	1 gram
Glycin	...	...	...	100 grains	5 grams
Potassium sulphocyanide	...	...	...	20 grains	1 gram
Potassium bromide	...	...	...	10 grains	0.5 gram
Cold water to make	...	...	...	40 ounces	1,000 c.cm.

47.—FOCAL SUPER-FINE GRAIN REPLENISHER SOLUTION

Water at 125°F. (52°C.)	...	...	...	30 ounces	750 c.cm.
Metol	...	...	...	100 grains	5 grams
Sodium sulphite, anhyd.	...	...	...	3½ ounces	90 grams
Borax, crystals	...	...	...	40 grains	2 grams
Sodium carbonate, anhyd.	...	...	...	80 grains	4 grams
Cold water to make	...	...	...	40 ounces	1,000 c.cm.

Important characteristics: The above formula contains the silver bromide solvent potassium sulphocyanide as does D.K.20. It is thanks to the investigations carried out in the Kodak laboratories that the newer application of this substance as a developer addition is due.

The Focal Super-Fine Grain Developer can be modified as follows:

(1) Without the potassium sulphocyanide it forms a normal fine-grain developer requiring about 12 minutes, but calls for 1½ times normal exposure.

(2) *Without the sulphocyanide but with double the sodium carbonate shown above, that is with 40 grains (2 grams), it provides a rather more brilliant-working fine-grain developer requiring the same development time and equally an increase in exposure time of 50 per cent.*

(3) *Exactly as given in the formula No. 46 it is a super-fine grain developer, somewhat slow and soft working, requiring 15–20 minutes development time and calling for double the normal exposure time.*

(4) *By doubling the quantity of sodium carbonate, as under 2, it becomes a rather more brilliant-working developer but still requires 15–20 minutes development time and the doubling of the normal exposure.*

Super-Fine Grain with Paraphenylenediamine

Paraphenylenediamine in solutions with high sulphite content but without other additions gives an exceedingly fine grain, but requires strong over-exposure and a very long development time. The same applies when additions of weak alkali are made (Nos. 48 and 49 of Table XXII).

This naturally led to a search for other additions which would have the effect of shortening the development time and details of such formulae appear in the Table XXII under Nos. 50–52, 54 and 55. Of these the best is the Sease developer No. 52, which provides a notably well-proportioned and reasonably quick-working fine-grain developer. The substitution of glycyl for metol in this developer has many advantages. Paraphenylenediamine itself has but poor keeping properties and loses its energy as a developer rather quickly. While developers which also contain metol are more energetic in action, their power to produce a fine-grain image is more or less lost; moreover, the presence of metol tends to mask the fact that the developer is becoming exhausted and hence there is danger of using the developer beyond its practically useful limits. These possibilities do

XXII.—SUPER-FINE GRAIN DEVELOPERS WITH PHENYLENEDIAMINES

Formula	48 LUMIERE & SEYE- WETZ	49 LUMIERE & SEYE- WETZ	50 SEYE- WETZ WEAK	51 SEYE- WETZ STRONG	52 SEASE	53 EDWAL 20	54 DEFEN- DER 51	55 SEYE- WETZ WEAK	56 SEYE- WETZ STRONG	57 WIND- ISCH	58 X33
Parapheny- lenediamine	10	10	10	5	10	10	10	—	—	—	—
Orthopheny- lenediamine	—	—	—	—	—	—	—	10	5	12	8
Metol	—	—	5	10	—	—	—	5	10	12	5.5
Hydroquinone	—	—	—	1.5	—	—	—	—	1.5	—	—
Glycin	—	—	—	—	6-12	5	2	—	—	—	1.5
Sodium sul- phite anhyd.	60	60	60	60	90	90	90	60	60	90	82
Borax	50	—	—	—	—	—	—	—	—	—	—
Trisodium phosphate	—	2	3.5	5.0	—	—	—	3.5	5	—	3
Potassium bromide ...	—	—	—	—	—	—	—	—	1.5	—	0.25
Special additions ...	—	—	—	—	—	Gradol 5	—	—	—	Sodium bisul- phite 5	—
Dev. time in minutes ...	60	60	7	15	15	18	30	7	13	12-13	16

The above quantities are to be taken as parts per thousand or grams per litre of water

not arise with the Sease developer, for as we know glycin is itself only a comparatively weak developer.

All paraphenylenediamine developers naturally possess the unpleasant character of this substance, hence the employment of the *ortho*-compound which has all the advantages of paraphenylenediamine without its disadvantages.

Formulae containing this compound are numbers 55 to 58 in Table XXII. Of these one of the best is that of Windisch, No. 57. It will be noted that this formula contains sodium bisulphite: the object of this addition is to neutralise the alkalinity of the sodium sulphite and hence to reduce slightly the energy of the developer, but also to enhance its fine-grain developing qualities. If the bisulphite is omitted somewhat shorter development time, about eight minutes less, is required, but the grain of the developed image is proportionately less fine. Such variations of formulae require to be handled with care, especially when dealing with negative material which has received critical exposure. It may be noted that the Windisch orthophenylenediamine developer is of universal application, and that the No. 57 formula has excellent life. Where a succession of films are being developed in the same solution, it is as well to increase the development time by one minute for each film after the first.

In the formula No. 53 in Table XXII, p. 151 there appears an addition of *Gradol*. This is a derivative of *para*-aminophenol and is related chemically to metol though of lower energy as a developer.

Meritol is the name of an excellent fine-grain developing agent placed on the market by Johnson and Sons. It is apparently a compound of paraphenylenediamine with pyrocatechin. Two formulae containing it are as follows:

59.—MERITOL FINE-GRAIN DEVELOPER

Meritol	135 grains	13.5 grams
Metol	25 grains	2.5 grams
Sodium sulphite, anhyd.	1 ounce	90 grams
Water to make	20 ounces	1,000 c.cm.

60.—MERITOL M.C.M. 100

Sodium sulphite, anhyd.	...	1½ ounces	88 grams
Meritol ...	...	140 grains	16 grams
Borax ...	...	20 grains	2.3 grams
Tribasic sodium phosphate	...	60 grains	6.9 grams
Potassium bromide	...	2 grains	0.2 grams
Water to make	...	20 ounces	1,000 c.cm.

Use hot water for mixing (about 125° to 140°F., 50° to 60°C.). Cool to 70°F. (20°C.) before using. If *Calgon* (p. 71) is used, dissolve 7 or 8 grains in water prior to making up developer (0.75 gram in 1,000 c.c.).

Developing Times at 70°F.

35 mm. films.

Kodak Panatomic X	...	12 minutes
Kodak Plus X	...	16 "
Kodak Super XX	...	20 "
Selo FP2	...	12 "
Selo HP2 and HP3	...	20 "

larger spools.

Kodak Super XX	...	20 minutes
Kodak Panatomic X	...	16 "
Kodak Verichrome	...	16 "
Selo Selo	...	16 "
Selo FP	...	12 "
Selo HP2 and HP3	...	20 "
Selo Selochrome	...	16 "

If the above solution is diluted in the proportion of one part of developer to nine of water, development time is *tripled* only, and not multiplied by nine, as might be imagined. Thus, if the normal time at full strength is twelve minutes, the time with the 9 to 1 dilution method is thirty-six minutes. Always give roll films a preliminary soak of three minutes in plain water with agitation to dissolve coloured backing which sometimes affects development.

By using after any Meritol developer a solution of caustic soda as an after-bath, *F. H. Lawrence* succeeded in obtaining increase in film speed without much loss in fine grain. His claims, which do not extend to all makes of films, have been confirmed by *P. W. Harris*. The film is first developed and then, *without rinsing*, it is immersed for thirty seconds in :

10% solution potassium or sodium bromide	...	...	...	1 part
10% solution caustic soda	...	...	...	1 part
Water	...	...	...	8 parts

Caution : Temperatures must be carefully maintained, not only of the developer but also of the after-bath and the rinse water. The after-bath is strongly alkaline, and if there is a temperature change reticulation (p. 284) may occur unless Formaline (p. 65) was added. The film after development and before fixing is tender, for which reason a hardening fixing bath is essential. After fixing, the film is no more liable to damage than when developed normally, and the temperature of the washing water is unimportant. With fresh film there will be a negligible increase in the fog level, but if the film is stale and out of date considerable fog may be obtained.

In a later publication the Author recommends actually pouring the 10% caustic soda solution into the developer (diluted 1:9) after that has acted by itself.

A fine-grain developing agent with an orthophenylene-diamine base is on the market as Super-Degrainol.

61.—SUPER-DEGRAINOL FINE-GRAIN DEVELOPER

Water at 125°F. (52°C.)	...	...	15 ounces	350 c.cm.
Super-Degrainol	...	...	240 grains	12 grams
Sodium sulphite, anhyd.	...	...	1½ ounces	40 grams
Borax	...	...	20 grains	1 gram
Cold water to make	...	...	20 ounces	500 c.cm.

Time of development 15 minutes. Full exposure is essential if the best results are to be obtained. This may be avoided by adding 10 grains ($\frac{1}{2}$ gram) of *anhydrous sodium carbonate* to the above formula but this slightly impairs the very fine-grain properties of the developer.

There have been numerous other formulae put forward as fine-grain developers, about some of which the most extravagant claims have been made. In quite a number of cases upwards of a dozen constituents are included, and it is not infrequently found that some of them are incompatible with the other constituents, or merely perform the same function. In other cases the concentrations present are obviously too small to influence the result materially. Such formulae, better called recipes, are like some old remedies into which all kinds of weird ingredients were added in the pious hope that even if they did no good they could do no harm.

Ready-made Super-Fine Grain Developers

Agfa Atomal—Finex. *Champlin* 15 and 16. *Defender* Panthermic 777. *Kodak* DK 20 and DK20R. *Edwards* Fine Grain. *Edwal* 20. *Fink* Roselieve X33 Thermolecular. *Johnson* M.C.M. 100—*Meritol*—Metol—Super Fine Grain. *Lafayette* Minigrain. *Mansfield* Micrograin 85. *Marshall* Fine Grain. *Morgan* Supersoup. *Oxford* Gamma D-Atomic. *P.A.C.* Super Degrainol. *Paco* Velvi-Dine. *Sears* Marvel Ultra Fine Grain. *Windisch* Ultra Fine Grain W665.

“Neutral” Fine-Grain Developers

All formulae for fine grain developers mentioned so far are of low alkalinity. Even the formula consisting only of Metol and Sodium Sulphite without any additional alkali

(see formula No. 43) has still an alkaline reaction as Sodium Sulphite itself is weakly alkaline. The only exception is the Windisch formula No. 57 containing Sodium Bisulphite which is acid and neutralises the weak alkalinity of the Sodium Sulphite.

This formula is furthermore characterised by its content of ortho-phenylenediamine and leads to a very fine grain. It had assumed so far that this high degree of fine graininess could only be obtained with developers containing either para- or ortho-phenylenediamine.

R. W. Henn and J. I. Crabtree have recently discovered that if the activity of a Metol-Sulphite developer is decreased by the addition of an acid substance to match that of the phenylenediamine developers, the graininess and emulsion speed values are the same. It therefore appears that the ortho-phenylenediamine in the Windisch formula is not essential but that its effect is based mainly on the neutralising action of the Bisulphite. Henn and Crabtree have found that the following formula gives a very high degree of fine graininess without containing a phenylenediamine :

62.—KODAK D25 DEVELOPER

Water (about 125°F.)	...	...	...	30 ounces	750 c.cm.
Metol	...	...	...	130 grains	7.5 grams
Sodium sulphite (desicc.)	...	...	...	4 ounces	100 grams
Sodium bisulphite	...	...	...	260 grains	15 grams
Water to make	...	...	...	40 ounces	1,000 c.cm.

A temperature of 28°C. (77°F.) is recommended and 50 per cent over-exposure is necessary. The following are the development times :

Kodak Super XX	...	...	...	35mm. 24 min. :	Roll film 18 min.
Kodak Plus X	...	...	...	35mm. 18 min.	
Kodak Panatomic X	...	...	...	35mm. 14 min. :	Roll film 18 min.
Kodak Verichrome	...	...	...		Roll film 18 min.

When processing without replenishment, an increase in time of about 15 per cent for each successive roll per litre is recommended. The developer should be replaced after 8 rolls per litre. The replenisher (DK25R) should be added

at the rate of $1\frac{1}{2}$ oz (45c.cm.) per roll of 80 sq. in. of film for the first 50 rolls per gallon (12 rolls per litre) and at $\frac{3}{4}$ of an ounce per roll for the next 50 rolls per gallon. After having developed a total of 100 rolls per gallon (25 rolls per litre) the developer should be replaced with a fresh solution.

63.—KODAK DK25R REPLENISHER

Water (about 125°F.)	...	...	...	30 ounces	750 c.cm.
Metol	...	...	...	175 grains	10 grams
Sodium sulphite (desicc.)	...	...	...	4 ounces	100 grams
Kodalk	...	...	...	350 grains	20 grams
Water to make	...	...	...	40 ounces	1,000 c.cm.

A Calcium Sulphite scum may be prevented by the use of an acid stop bath.

A compromise fine grain developer containing only 7.5 grams of Sodium Sulphite per litre is recommended when the long time or higher temperature required by the above formula is inconvenient and when extreme fine grain is not necessary. Such a developer needs about 70 per cent of the developing time of No. 62 and gives about $\frac{2}{3}$ of its fine grain result. It can be replenished with the same replenishment solution No. 63 at the rate of $\frac{3}{4}$ —1 oz. per roll.

PHYSICAL DEVELOPMENT

Physical developers, which differ from chemical developers in that *they contain silver salts*, were originally used almost exclusively for special purposes in scientific and technical photography. More recently they have been found of particular interest in general photographic work, owing to their property of *developing a fine grain*.

Formulae for physical fine-grain developers specially devised for modern sensitive material were put forward by Odell and improved formulae were put forward by Turner.

The process consists of the following steps.

- (1) *Treatment in a fore-bath.*
- (2) *Development in the silver containing solution.*
- (3) *Fixing in an acid-hardening fixing bath.*
- (4) *Washing and drying.*

Development can be carried out in a dish, but a *tank is preferable*. It is, of course, essential that the material of the vessel, whether dish or tank, should not be such as to precipitate the silver from the bath. *Glass, porcelain, hard rubber or bakelite* can be used, but *metals* are not permissible, with the exception of certain types of *stainless steel*.

64.—FORE-BATH FOR PHYSICAL DEVELOPMENT

Potassium iodide	...	...	...	100 grains	5 grams
Sodium sulphite, anhyd.	...	...	...	$\frac{1}{2}$ ounce	12.5 grams
Water to make	...	...	...	20 ounces	500 c.cm.

The film is placed in the dish or tank *dry* and the fore-bath is then poured *upon it* and allowed to act for 3-4 minutes. The fore-bath is then poured off, and if kept in a *brown glass bottle* can be used again and again, usually serving for at least *eight treatments*. The film is then rinsed well in two changes of water. *Panchromatic films* may be *desensitised* in the usual manner before being placed in the fore-bath (see page 206).

For development a concentrated silver-stock solution is prepared. It is of the utmost importance that the directions for making this solution be *carefully and accurately* followed.

65.—SILVER STOCK SOLUTION FOR PHYSICAL DEVELOPMENT

A. Silver nitrate	...	...	...	$\frac{1}{2}$ ounce	12.5 grams
Distilled water	...	...	...	8 ounces	200 c.cm.
B. Sodium sulphite, anhyd.	...	...	...	2 ounces	50 grams
Water, about	...	...	...	20 ounces	500 c.cm.

The two solutions are prepared warm (about 120°F., 50°C.) and allowed to cool to about 75°F. (24°C.). Then solution A, the silver nitrate, is poured slowly and with constant stirring into solution B, the sulphite. Stirring must be continued until the white precipitate which forms at first is completely dissolved. When this is accomplished there is added :

Hypo crystals	...	...	...	6 ounces	150 grams
Water to make	...	...	...	40 ounces	1,000 c.cm.

This solution is stable and has good keeping properties.

Then the exciter-solution is prepared as follows.

66.—EXCITER SOLUTION FOR PHYSICAL DEVELOPMENT

Metol	...	...	...	40 grains	2 grams
Hydroquinone	...	...	...	80 grains	4 grams
Sodium sulphite, anhyd.	...	...	...	1 $\frac{3}{4}$ ounces	40 grams
Tribasic sodium phosphate	...	...	...	1 $\frac{1}{4}$ ounces	32 grams
Distilled water to make	...	...	...	40 ounces	1,000 c.cm.

When the film has been treated in the fore-bath and received its two good rinsings it is placed in the developer consisting of silver stock solution 1 part by volume, exciter solution 1 part by volume, water 3 parts by volume.

In order to determine the *correct time for development*, Turner has devised the following colour-time test. A drop of the developer, ready for use, is placed on a small piece of *Ilford "Clorona"* paper which has already been exposed for 10 seconds to a lamp. The paper with the drop of developer on it is now placed in white light and the time noted which is required for the wetted paper to attain a yellowish-red coloration. This is usually 70-75 seconds. This time multiplied by the factor from the following Table **XXIII** gives the time required for development, for the particular film used, in order to attain a *gamma* of 0.8.

The Table **XXIII** actually gives the total development time for each film, but it is always preferable to make a test. Note that the factor is multiplied by seconds, but in the Table **XXIII** the times are given in minutes.

XXIII.—CORRECT TIME OF PHYSICAL DEVELOPMENT

<i>Film</i>	<i>Factor</i>	<i>Development time</i>
Agfa Ultra	28	34 minutes
ISS	24	29 "
Isopan F and FF	22	26 "
Gevaert Panchromosa	35	42 "
Microgran	22	26 "
Kodak Super XX	42	50 "
Plus X	26	43 "
Panatomic X... ..	28	34 "
Perutz Peromnia	24	29 "
Perpantic	16	19 "
Pergrano	24	29 "
Selo HP2 and FP	30	36 "
Zelss-Ikon Panchrom	45	54 "

When development is complete the film is given a good rinse and is then fixed in a normal acid-hardening and fixing bath. (See page 213.)

As the silver bromide in the emulsion will have been partially converted into iodide in the fore-bath, a *much longer fixing time* will be necessary than that required for a normally developed negative, certainly not less than about *20 minutes* : after that the film should be well washed and, before drying, the developed surface should be gently wiped over with a wad of cotton wool to remove any loose deposit of reduced silver.

Further formulæ for physical development have been devised as a result of the careful investigations of *F. R. McQuown*. It is claimed that by this method the over-exposure usually called for is not necessary.

67.—FORE-BATH FOR PHYSICAL DEVELOPMENT (*F. R. McQUOWN*)

Potassium iodide	120 grains	6 grams
Sodium sulphite, anhyd.	280 grains	14 grams
Borax powdered	50 grains	2.5 grams
Water to make	20 ounces	500 c.cm.

All the chemicals can be dissolved together. The borax may be omitted if the bath is to be used up within a week or so. The bath can be used *repeatedly*. The film is immersed, without previous wetting, for *40 seconds* in the fore-bath with vigorous agitation. After the fore-bath treatment rinse the film in water for *20 seconds* and proceed to develop in the working physical developer solution.

68.—PHYSICAL DEVELOPER STOCK SOLUTION

(F. R. McQUOWN)

Sodium sulphite, anhyd. ...	...	...	2 ounces	100 grams
Silver nitrate, cryst. ...	...	...	130 grains	13 grams
Borax, powdered ...	...	...	130 grains	13 grams
Hypo (Sodium thiosulphate) ...	...	...	2½ ounces	120 grams
Water to make ...	...	...	20 ounces	1,000 c.cm.

The *sulphite* should be dissolved in about 14 ozs. (700 c.cm.) of water at about 120°F. (50°C.). The *silver nitrate* is dissolved in about 4 ounces (200 c.cm.) of water and slowly added to the *sulphate solution* which is vigorously stirred. The other chemicals are then dissolved in the order named and the volume made up to 20 ounces (1,000 c.cm.).

The plate or film is immersed in the following working solution :

69.—WORKING PHYSICAL DEVELOPER SOLUTION

(F. R. McQUOWN)

Developer stock solution ...	...	...	1 ounce	25 c.cm.
Water to make ...	...	...	4 ounces	100 c.cm.
Amidol ...	...	...	6 grains	0.25 grams

The working solution should be used within about ten minutes of making up.

Average times of development : 16 minutes at 60°F. (15°C.), 11 minutes at 65°F. (18°C.), 7 minutes at 70°F. (21°C.).

Tap water is satisfactory for all solutions. The stock solution can be filtered if desired. Allow to stand for about 12 hours and then filter through a *Whatman No. 2* filter paper.

When development is complete a short wash is given before fixing in an acid hardening and fixing bath (p. 213).

TANNING DEVELOPERS

It has already been mentioned that in the process of development oxidation products are formed from the developing agents or substances, and these products have certain properties of varying interest and application in photography. We already know that they can affect the colour of the negative, stain fingers, and they can also bring about the *tanning of the gelatine of the emulsion*. This process is favoured by a low concentration of *sulphite* in the developer or, better still, by its complete *absence*. Under these conditions the tanning of the gelatine is proportional to the quantity of silver reduced, hence the tanning will be *greatest in the most strongly blackened parts of the negative*.

This property has been made use of in a number of ways in photo-

graphy. For example, in the preparation of *tanned relief pictures*, in which the untanned gelatine, that is the gelatine existing in the unexposed parts of the picture, is dissolved away by warm water. In certain processes of colour photography and in particular in the *making of colour prints* this process is of great importance.*

In ordinary black-and-white photography the tanning effect on gelatine can be made use of in the following way. Wherever the gelatine has been tanned by the developer, the access of further developing solution to the film is rendered difficult and development slowed down. This braking effect on development is strongest in those parts of the negative which have received the heaviest exposure, that is in the high lights. Hence the further development of the high lights is held back, and a certain degree of compensation or *equalising of contrast* is attained; another point is that as the action of the developer is almost wholly on the surface of the emulsion film, *halation will not be shown* because the effects of halation occur in the depths of the emulsion to a very much greater extent than on the surface.

Important characteristics: The following formula is an example of a tanning developer having properties such as have just been described.

70.—TANNING DEVELOPER

Pyrocatechin	...	...	...	40 grains	2 grams
Sodium sulphite solution 5%	...	...	...	2 drams	5 c.cm.
Caustic soda solution 5%	...	...	...	4 drams	10 c.cm.
Water to make	...	...	...	40 ounces	1,000 c.cm.

* Development time is 15—20 minutes.

Caution: This developer should not be used for plates which have a brown anti-halo layer between the emulsion and the glass.

With the exception of *glycin* most of the usual developing agents will produce a tanned image when used with a similar bath to the above, but pyrocatechin is the most powerful tanning agent among them.

It has found special application in those conditions where very *rapid development* is essential; it is then used in developers containing a *much higher alkali content* than that quoted above, and development times as low as 25 seconds have been attained by its use.

* See "Making Colour Prints," by Jack H. Coote. The Focal Press, London, W.I.

CHROMOGENIC DEVELOPERS

The word chromogen is applied to materials which when oxidised produce colours: its use in photography is comparatively recent, but is of material significance in the development of modern colour photography.

We have already seen that the oxidation products of developing substances have dyeing properties and can colour the silver image and stain gelatine, etc. Until recently this property was not utilised in practice to any great extent. Some small use was made of a brown-tone developer for *lantern slides*, still more rarely for *papers*, generally a *pyrocatechin sulphite free developer* of the type described on pages 159-160.

Today this dye- or colour-producing property of developers assumes great importance for the *Kodachrome*, *Kodacolor* and *Agfacolor* processes both use this principle. The oldest example of the formation of a dye image by the development process is *pyro*, which in an *alkali rich* formula does not produce a black silver but one which is more or less brown or even yellow. If such a negative be treated with *Farmer's reducer* so that the whole of the *silver image* is removed, there still remains a clearly perceptible *dye image of yellow-brown colour*.

Starting from this point, *Homolka* sought for materials which could act not only as developers but also as stepping-stones to dye products, and he found such compounds in *indoxyl* and *thioindoxyl*, which are capable of developing the latent image in exposed photographic materials and are oxidised by the development process to the deeply-coloured *indigo dyestuffs*.

The next step in the process was supplied by the researches of *Fischer* and *Siegrist* who discovered that many usable developers had the property of forming dyestuffs under the influence of the developed image. *Paraphenylenediamine*, *para-aminophenol* and *allied compounds* possess this property to a particular degree, and are able through simple oxidation with *phenols* and *amines* to produce a *whole range of dyestuffs* which are known as *indophenols*, *indonanilines* and *indamines*.

The oxidation which brings about the formation of these dyestuffs can be easily effected by the exposed silver bromide in the photographic film. Hence it is possible by direct development to obtain a *reduction of silver* and a *proportional formation of dyestuff*, given, of course, that the *dyestuff* is *insoluble in water* and remains precipitated where it is formed, thus *producing a dye image*.

The phenols and amines used with the developers are called *couplers* or *coupling bodies* because they act between the developer on the one hand and the dyestuff on the other. By the choice of suitable and specific coupler bodies a very big range of compounds has been produced, many of them the subject of patents, but the work of the researchers already named has provided quite a number of valuable and useful couplers.

The origin and character of the colour depends in large degree on the developer and by the introduction of colour-deepening groups it is possible to produce a range of shades. For example, using *dichloro-naphthol* as coupler and varying the developer from *paraphenylenediamine* to some of its derivatives one can obtain the shades in table **XXIV**. Of these three developers the third is perhaps the most easily obtainable and finds a place in many chromogenic developers. The *diethyl* compound of *paraphenylenediamine* is similar in its action.

The wide variety of colour tones obtainable through the particular choice of developer and coupling body is of great importance in the application of the method for colour photography, particularly in the preparation of separation pictures in the correct basic colours.

The great importance of such developers and couplers in colour photography will be obvious. There is also an interesting and fascinating field in the development of *lantern slides* and of positives on *paper*, for not only can one obtain a big range of colours by the choice of developer and coupler, but one can also remove the silver image in part or entirely by the use of *Farmer's reducer*.

XXIV.—CHROMOGENIC DEVELOPER SUBSTANCES AND COUPLERS

Paraphenylenediamine	...	...	...	...	Blue-red or violet
Paratoluylenediamine 1 : 2 : 5	...	...	...	...	Blue
Dimethyl-paraphenylenediamine	...	...	...	...	Blue-green

Further changes in colour can be obtained by the choice of different couplers.

Alpha naphthol	...	...	...	...	Blue
2 : 4 Dichlornaphthol...	...	...	...	...	Blue-green
Trichlornaphthol	...	...	...	...	Green-blue
Pentabromnaphthol	...	...	...	...	Green
p-Nitrobenzylcyanide...	...	...	...	...	Yellow
1 : Phenyl—3 : Methyl—5 : pyrazolone	...	...	...	...	Red

A. G. Tull has pointed out that it is better not to use a colour developer in the first instance for lantern slides or paper prints, but to develop, fix and wash in the usual way and then to *bleach* with *ferricyanide bromide* bleacher and *re-develop* with the colour developer. He gives the following formula :

71.—COLOUR DEVELOPER (A. G. TULL)

Diethyl or dimethylparaphenylene-

diamine	...	...	...	20 grains	1 gram
Sodium sulphite, anhyd.	...	...	...	100 grains	5 grams
Potassium carbonate	...	...	...	$\frac{3}{4}$ ounce	20 grams
Water to make	...	...	...	40 ounces	1,000 c.cm.

In the following series of formulae for colour formers those marked with an asterisk are protected by patent, and pictures produced by their aid must not therefore be dealt with commercially in any way.

72.—MAGENTA COLOUR FORMER

p-nitrophenylacetoneitrile	...	...	160 grains	8 grams
Methylated spirits...	...	...	4 ounces	100 c.cm.

73.—BROWNISH-YELLOW COLOUR FORMER*

Cyanacetanilide	...	...	...	8 grains	0.4 gram
Methylated spirits...	...	...	...	2 ounces	50 c.cm.
Acetone	...	...	...	2 ounces	50 c.cm.

74.—BLUE COLOUR FORMER

Alpha naphthol	...	...	...	14 grains	0.7 gram
Methylated spirits...	...	...	...	4 ounces	100 c.cm.

75.—BLUE-GREEN COLOUR FORMER

Dichloro-alpha naphthol	...	...	...	20 grains	1 gram
Methylated spirits...	...	...	...	4 ounces	100 c.cm.

76.—PALE-GREEN COLOUR FORMER*

Dichlor-ortho-cresol	...	...	...	18 grains	0.9 gram
Methylated spirits...	...	...	...	4 ounces	100 c.cm.

77.—YELLOW COLOUR FORMER*

Ortho-chloroacetoacetanilide	...	...	...	20 grains	1 gram
Methylated spirits...	...	...	...	4 ounces	100 c.cm.

For use take about 2 drams (10 c.cm.) of the *colour former solution* as detailed above for each 4 ounces (100 c.cm.) of developer solution.

When once used, such developer must be thrown away and a fresh portion used for each separate development.

TROPICAL DEVELOPERS

With any normal developer *increase of temperature means increased rate of development and increased danger of fog*, but the greatest danger of all is that at high temperatures the gelatine of the *emulsion swells inordinately* and becomes very weak and *wrinkles or even melts entirely*.

The name tropical developer is given to those formulae in which direct provision has been made to avoid dangerous swelling, either by the addition of a substance which *reduces the swelling* of the gelatine or by *balancing the ingredients* and eliminating those which cause swelling to excess.

In general *the more alkaline the developer the more the gelatine swells* and the more rapidly development takes place; hence an alkali-free developer of the *amidol* type or one of the *mildly alkaline* fine-grain developers is preferable to one with normal alkali content when working at high temperatures.

The substance usually added to tropical developers to reduce the swelling of gelatine is *sodium sulphate* (*Glauber's salts*). It is essential that it should be present in *high concentration* and not less than 4 ounces (100 grams) per 40 ounces (1,000 c.cm.).

A general rule in the case of normal developers is to add a *weight of sodium sulphate equal to the combined weights of the carbonate and sulphite present* in the formula. In alkali-free developers it should be equal in weight to the sulphite present, or *not less than 10 per cent of the total solution weight*, whichever is the larger.

It might be thought that addition of *formaldehyde*, which hardens the gelatine, would be useful, but it will be remembered that formaldehyde reacts with *sodium sulphite* to produce *caustic soda*, and this will naturally increase the alkalinity of the developer. Hence when tropical developers are used the negatives are always fixed in a combined *fixing*

and hardening bath, or are hardened after development and before fixing.

78.—KODAK (DK15) TROPICAL DEVELOPER

Metol...	...	...	...	200 grains	5.7 grams
Sodium sulphite cryst.	...	14 ounces	175 grains	180 grams	
Kodalk	...	...	1 ounce	335 grains	22.5 grams
Potassium bromide	...	...	...	67 grains	1.9 grams
Sodium sulphate cryst.	...	8 ounces	175 grains	105 grams	
Water to make	...	...	...	80 ounces	1,000 c.cm.

The correct development times at various temperatures are given in the following table.

Temperature	Dish Development	Tank Development
65°F. 18°C.	.. 10 minutes	12½ minutes
70°F. 21°C.	.. 8 "	10 "
75°F. 24°C.	.. 6½ "	8 "
80°F. 26.5°C.	.. 5 "	6 "
85°F. 29.5°C.	.. 3½ "	4½ "
90°F. 32°C.	.. 2½ "	3 "

Move the film about at the commencement of development to ensure even action; when development is complete, rinse for a couple of seconds in water and harden for 3 minutes in the following tropical hardener.

79.—TROPICAL HARDENER

Water	...	40 ounces	1,000 c.cm.
Chrome alum	...	1½ ounces	30 grams
Sodium sulphate cryst.	...	4 ounces	100 grams

This bath should have a *violet blue colour* by artificial light ; if it appears *yellow-green* it is exhausted and must be replaced by a fresh bath.

The rinse between development and hardening may be omitted if the gelatine film appears very soft, but not otherwise. Fix in a normal hardening fixing bath. (See page 213.)

The temperature of the wash water should not be over 95°F. (35°C.).

Factorial and Time-Temperature Development

Alfred Watkins' factorial system of development played a valuable and important part in photography for many years. Although to-day it is but little used, largely because development by inspection has been superseded by more modern methods, it is still of sufficient interest to warrant a description.

In 1893 Watkins discovered that there was a *definite relation* for almost every developer between the *time of appearance of the first trace of developed image and the time that would be required for the full development of the image*. This was the foundation of his factorial system of development.

The "time of appearance" is the exact time elapsing between the pouring on of the developer and the first appearance of any trace of image. This "time of appearance" is multiplied by a factor which Watkins worked out for each particular developer.

The factors for the more important developing agents are as follows:

XXV.—WATKINS' FACTORS

Chlorquinol	...	...	...	...	...	...	...	Factor	18
Amidol (concentration 4 parts per 1,000)	...	...	...	...	...	...	...	"	5
Pyrocatechin	...	...	...	...	...	...	...	"	10
Glycin	...	...	...	...	...	...	...	"	8
Hydroquinone	...	...	...	...	...	...	...	"	5
Metol	...	...	...	...	...	...	...	"	30
Metol-hydroquinone (normal formulae)	...	...	...	...	...	...	...	"	14
Pyrogallol	...	...	...	...	...	...	...	"	7

Pyrogallol and *amidol* do not obey the rule strictly, as with these two substances the concentration of developing agent can vary the factor, and in some other cases excessive dilution and wide variations in temperature may also influence the results.

In the case of *combined developers* such as *metol-hydroquinone* the factor is the average of the factors of the two constituents if they are present in equal proportions. Thus with equal parts of metol and hydroquinone the factor would be $5 + 30 = 35$ divided by two $= 17\frac{1}{2}$. If, however, there were 2 parts of metol and 3 of hydroquinone, then the factor would be $30 + 30 + 5 + 5 + 5 = 75$ divided by five $= 15$. Using this method it is a simple matter to estimate the factor for the most generally-used developers.

The fact that the factor failed when the temperature varied notably from the normal induced *Andresen* to produce a formula that could be varied in composition to suit varying temperatures:

80.—TIME-TEMPERATURE DEVELOPER

A. Metol	...	...	...	...	200 grains	10 grams
Sodium sulphite, anhyd.	...	...	...	...	2 ounces	50 grams
Water to make	...	...	...	...	40 ounces	1,000 c.cm.
B. Potassium carbonate	...	...	...	...	1½ ounces	40 grams
Potassium bromide	...	...	...	...	10 grains	0.5 gram
Water	...	...	...	...	16 ounces	400 c.cm.

The solutions are kept in the room in which development is to take place. It is then only necessary to note the temperature of the room and to use the following proportions of the solutions to obtain constant development time.

XXVI.—PROPORTIONAL SOLUTION QUANTITIES

Temperature	59° F. = 15°C.	...	take of A	50 c.cm.	of B	39 c.cm.
60.8°F. = 16°C.	...	"	50	"	30	"
62.6°F. = 17°C.	...	"	50	"	23	"
64.4°F. = 18°C.	...	"	50	"	18	"
66.2°F. = 19°C.	...	"	50	"	14	"
68° F. = 20°C.	...	"	50	"	11	"
70° F. = 21°C.	...	"	50	"	9	"
71.6°F. = 22°C.	...	"	50	"	7	"
73.4°F. = 23°C.	...	"	50	"	5	"
75° F. = 24°C.	...	"	50	"	4	"
77° F. = 25°C.	...	"	50	"	3	"
79° F. = 26°C.	...	"	50	"	2	"
82° F. = 28°C.	...	"	50	"	1	"
86° F. = 30°C.	...	"	50	"	0	"

Development time is from 5-7 minutes. The method is of interest for tropical development as *sodium sulphate* can be added to the solutions to prevent excessive swelling of the gelatine (see page 164).

HIGH SPEED DEVELOPERS

There are numerous occasions in photographic practice when it is important that development shall be as rapid as possible. Two examples may be given, *press photography* where the news editor is waiting for the picture, and in *X-ray work* where it often happens that the surgeon must await the result of an X-ray picture before continuing a particular operation.

81.—HIGH SPEED DEVELOPER (H. JÄNICKE)

Hydroquinone	...	...	...	1½ ounces	30 grams
Sodium sulphite, anhyd.	...	...	...	1 ounce	25 grams
Caustic potash	...	...	...	2½ ounces	60 grams
Water to make	...	...	...	40 ounces	1,000 c.cm.

To reduce developer fog add ¼ ounce (20 c.c.) of a solution of phenosafranin 1 : 1,000.

At 68-70°F. (20-22°C.) development is complete in about 25 seconds.

Even more rapid development can be obtained by using the two-bath method. The principle of this method, as we shall see later (see pages 171-175), is the *separation of the developing agent from the alkali*. This allows of very highly-concentrated baths being used. For example, one can bathe the film for 10 seconds in a solution of 2 ounces (50 grams) *hydroquinone* in 40 ounces (1,000 c.cm.) water, a temperature as high as 75°F. (24°C.) can be used; then without rinsing, the film is plunged for one or two seconds into a 30 per cent solution of *caustic potash*.

Even greater speed and better contrast gives:

82.—ALTERNATIVE HIGH SPEED DEVELOPER

Hydroquinone	...	...	...	...	2 ounces	50 grams
Sulphurous acid, 5-10% solution (not sulphuric acid)	...	...	...	...	10 ounces	250 c.cm.
Water to make	...	...	...	...	40 ounces	1,000 c.cm.

The alkali solution is the same as before

It is quite possible that the heat of reaction at the moment of contact between the acid-soaked film and the alkali solution plays an important part in speeding up the development.

Methods of high-speed development have been investigated very completely by A. Charrion and S. Valette.

83.—HIGH SPEED DEVELOPER BY A. CHARRION AND S. VALETTE

Metol	...	...	...	...	1/2 ounce	15 grams
Hydroquinone	...	...	...	...	1/2 ounce	15 grams
Sodium sulphite, anhyd.	...	...	...	...	2 ounces	50 grams
Potassium bromide	...	...	...	...	20 grains	1 gram
Sodium hydroxide	...	...	...	...	1 ounce	30 grams
Water to make	...	...	...	...	40 ounces	1,000 c.cm.

Development can be carried on in between 25-40 seconds, at a temperature of 68°F. (20°C.).

After development the film is plunged at once into the following stop-bath.

84.—STOP-BATH FOR HIGH SPEED DEVELOPER

Water	...	...	...	...	9 ounces	180 c.cm.
Acetic acid	...	...	...	...	1 ounce	20 c.cm.

After a second or so, and without any intermediate rinse, it is then placed in the following rapid fixing bath.

The temperature of this bath may be 68-70°F. (20-21°C.).

If a time of development of 10 seconds be required, increase the bromide content of the developer to 160 grains (8 grams) and raise the temperature to 120°F. (50°C.).

85.—RAPID FIXING BATH AFTER HIGH SPEED DEVELOPING

Hypo.	...	...	...	...	10 ounces	250 grams
Bisulphite lye (see p. 60)	...	...	...	...	1 ounce	25 c.cm.
Ammonium chloride	...	...	...	...	2 1/2 ounces	60 grams
Water to make	...	...	...	...	40 ounces	1,000 c.cm.

86.—FOCAL MAXIMUM ENERGY DEVELOPER

A. Water at 125°F. (52°C.)	...	...	14 ounces	350 c.cm.
Hydroquinone	...	...	1½ ounces	32 grams
Sodium sulphite, anhyd.	...	...	1 ounce	25 grams
Phenosafranine 1 : 1,000 solution	...	...	1½ drams	5 c.cm.
Potassium bromide	...	...	10 grains	0.5 gram
Cold water to make	...	...	20 ounces	500 c.cm.
B. Cold water	...	...	14 ounces	350 c.cm.
Caustic potash	...	...	2 ounces	50 grams
Sodium sulphite, anhyd.	...	...	1 ounce	25 grams
Potassium bromide	...	...	10 grains	0.5 gram
Cold water to make	...	...	20 ounces	500 c.cm.

Important characteristics: The above formula provides a high energy developer which gives good service in all cases where great speed of development is important, e.g., press photography, process work, X-ray films, etc. It is also useful in handling *under-exposed negatives*. In general it is not a *fog-producing developer*, but should overmuch fog appear on certain films then the bromide content can be raised somewhat.

By mixing equal parts of A and B a high speed developer is obtained which will develop a negative in 20–30 seconds, with the advantage that the weakest details in the shadows will be brought out.

If the *greatest contrast* is required and not mere speed in development, then increase the bromide in solution A to ¾-ounce (18 grams) and mix as follows, 1 part A, 1 part B, and 2 parts water. In such a case the time of development will be 2½–3 minutes.

An economical method of using this formula is the two-bath method which is described on pages 171–172. Using this method for high speed development, the film is placed in solution A for 15–20 seconds, and then without any rinse plunged into solution B for about 10 seconds, or for so long as no further progress in development can be seen.

For contrast development the *bromide* content of solution A should be revised as already mentioned, then give the film 2 minutes in solution A and 1 minute in B.

Remember that in the two-bath method *no development* will take place or be perceptible in solution A, in which the film will merely saturate itself; hence there will be no exhaustion of the chemicals, only loss through solution being carried over by the film into solution B. As a result, solution A can be used to the last drop. Solution B, on the other hand, is used up rather quickly, becoming *discoloured by oxidation* and by carried over solution so that it must be frequently renewed.

Caution: The stock solutions A and B keep indefinitely, but once they are mixed together deterioration is rapid.

As solution B is a strongly *caustic alkaline solution*, the fingers should not be dipped into it; plate or film holders should be used, or rubber gloves worn.

As the high speed developer has a very high development energy the question of fog-free working is of importance. In this direction the addition of a developer improver as mentioned on pages 70-71 can be of very real service in reducing fog.

Ready Made: Kodak—X-ray Ultra-Rapid Developer Powder.

TWO-BATH DEVELOPMENT

In the ordinary process of development the *developing agent becomes used up* and various reaction products, particularly *bromides*, *slow the action* of the bath. To meet these conditions it is necessary to increase time of development, or to add a replenishing solution. There exists another method of overcoming these difficulties, and that is the use of *separate baths for the developing agent and the alkali*, or, as it is generally called, two-bath development.

The *first bath* contains only the *developing agent* and the *preservative*, and therefore *no or only incomplete development* takes place in it. What happens is that the exposed film or plate becomes saturated with the solution. As *no chemical action* is taking place, the properties of the bath do not alter; all that happens is that each plate or film treated in it removes a small quantity of the solution when taken out. Hence such a bath being constant in properties

allows very *constant results* to be obtained. As the concentration of such a bath can be *altered at will*, so can the desired *grade of contrast* in the negative be influenced within comparatively wide limits and where one type of material is being used the optional conditions can be obtained and maintained.

The actual development takes place in the *second bath* which contains the *alkali*: here chemical action takes place but not in quite the same degree as in a normal developer. The film is already *swollen and saturated* with fresh developer solution, and the process of development is therefore *speedy and complete*. Moreover, as the bath only contains alkali it is *cheap* and can be *renewed at frequent intervals*.

The two-bath method has *other advantages* as well, one of which is that a large tank can be used for the developing agent solution, but a small one for the alkali. The method is worthy of more attention than it has hitherto received.

It permits of very economical working and also of the attaining of consonant results in which the time of treatment in the two baths is controlled and the alkali bath renewed from time to time.

87.—TWO-BATH DEVELOPER

1. Metol	...	...	...	100 grains	5 grams
Hydroquinone	...	...	...	40 grains	2 grams
Sodium sulphite, anhyd.	...	...	...	4 ounces	100 grams
Sugar (cane)	...	...	...	4 ounces	100 grams
Sodium bisulphite	...	...	...	100 grains	5 grams
Water to make	...	...	...	40 ounces	1,000 c.cm.
2. Sodium sulphite, anhyd.	...	...	...	4 ounces	100 grams
Sodium carbonate, anhyd.	...	...	...	200 grains	10 grams
Water to make	...	...	...	40 ounces	1,000 c.cm.

The addition of *sugar* and *bisulphite* to the first bath has the effect of retarding the action of the bath and at the same time preventing the appearance of any image due to the slight *alkalinity* of the *sulphite*.

The negative material should have about *5 minutes* in solution 1, and will require from *4-6 minutes* to develop in solution 2.

88.—TWO-BATH FINE-GRAIN DEVELOPER (H. STOECKLER)

1. Metol	...	...	...	...	100 grains	5 grams
Sodium sulphite, anhyd.	...	...	...	...	4 ounces	100 grams
Water	...	...	...	...	40 ounces	1,000 c.cm.
2. Borax	...	...	...	...	200 grains	10 grams
Water	...	...	...	...	40 ounces	1,000 c.cm.

The time that films should remain in solution 1 varies with different makes of film; the more important types are as follows:

Agfa Isopan FF	...	2½ minutes	Kodak Panatomic X	...	4 minutes
Selo FP	...	3 "	Perutz Pergrano	...	4 "
Agfa Isopan F	...	4 "	Kodak Plus X	...	4-5 "
Agfa Isochrom F	...	4 "	Perutz Perpartic	...	4-5 "

The development time for all the films in bath 2 is about 3 minutes.

H. Stoeckler sets out the advantages of the two-bath fine-grain developer method as follows: (1) *Harmonious compensation for great contrasts* when used for the new and harder films, soft negatives of a gradation which allows of easy enlarging. (2) The effective *sensitivity* of the film is *not materially reduced*. If it is imperative not to lose any sensitivity, only the first bath should be used and the development carried out for about six minutes. (3) As it is development at the surface, there is *less halation and irradiation*, and the best possible rendering of sharpness. (4) *Great economy and cheapness* of the solutions, which last longer and can be used many times.

89.—TWO-BATH KODAK DK20 SUPER-FINE GRAIN (SYMON)

1. Water distilled at 125°F. (52°C.)	...	15 ounces	750 c.c.
Metol	...	45 grains	5 grams
Sodium sulphite, anhyd.	...	2 ounces	100 grams
Potassium thiocyanate	...	8 grains	1 gram
Potassium bromide	...	4 grains	0.5 gram
Distilled water to make	...	20 ounces	1000 c.c.
2. Kodalk	...	175 grains	20 grams
Water (distilled)	...	20 ounces	1000 c.c.

For use the solution 2 is diluted 10 times (50 c.c. made up to 500 c.c. with water). This is thrown away after using for the development of one film.

90.—REPLENISHER SOLUTION FOR SOLUTION 1, KODAK DK20

Water distilled (about 125°F.)	...	...	15 ounces	750 c.c.
Metol	...	...	65 grains	7.5 grams
Sodium sulphite, anhyd.	...	...	2 ounces	100 grams
Potassium thiocyanate	...	...	44 grains	5 grams
Distilled water to	...	...	20 ounces	1000 c.c.

In use the total bulk of solution 1 is kept at 1000 c.c. by filtering back into the bottle after use. 20 c.c. of Replenisher is added to the amount required for the tank for each film after the first. Development time is thus kept constant.

The following development times in minutes are correct for a gamma of .7 at 65°F.

					1. Bath	2. Bath
Kodak	Panatomic X	...	...	...	6½	3½
	Plus X	...	...	...	10	3½
	Super XX	...	...	...	15	3½
Ilford	Selo H.P.2.	...	...	...	18	3½
	Selo F.P.2.	...	...	...	6	3½

As already noted on page 168 the principle of two-bath development may be usefully combined with high speed development. The high speed two-bath developer meets the requirements of those who must complete the processing of exposed films in the shortest possible time, e.g., in news photography. The following method permits of complete processing within fifteen minutes.

91.—HIGH SPEED TWO-BATH DEVELOPER (AGFA)

- Hot water (125°F. or 52°C.) ... 30 ounces 750 c.c.
Metol ... 100 grains 5 grains
Sodium sulphite, anhyd. ... 1½ ounces 30 grams
Hydroquinone ... 200 grains 10 grams
Water to make ... 40 ounces 1,000 c.c.
- Hot water (125°F. or 52°C.) ... 30 ounces 750 c.c.
Sodium carbonate ... 5 ounces 125 grams
Water to make ... 40 ounces 1,000 c.c.

Solutions 1 and 2 are stored separately and used

separately. Solution 2 must be replaced when it becomes badly discoloured. Both solutions are used at full strength.

For development immerse films for one minute in solution 1, agitating the whole time, then transfer film to solution 2 for one minute. The solutions should have a temperature of 70°F. (21°C.) If bath temperature be 75°F. (24°C.) then only 45 seconds should be given in each bath, but should bath temperature fall to 65°F. (18°C.) then development time in each bath must be 1 minute 15 seconds.

Contrast can be controlled by varying the time of immersion in solution 2 as contrast increases with increasing time of immersion in this solution.

As soon as development is judged complete plunge film into a stop-bath consisting of a 1% solution of acetic acid.

92.—QUICK FIXING BATH (AGFA)

1.	Hot water (125°F. or 52°C.)	...	20 ounces	500 c.cm.
	Hypo	...	14 ounces	350 grams
2.	Hot water (125°F. or 52°C.)	...	6 ounces	150 c.cm.
	Sodium sulphite, anhyd.	...	$\frac{1}{2}$ ounce	15 grams
	Acetic acid (28%)	...	$1\frac{1}{2}$ ounces	45 c.cm.
	Potash alum	...	$\frac{1}{2}$ ounce	15 grams
	When fully dissolved add solution 2 to solution 1 and then add			
	Water to make	...	40 ounces	1,000 c.cm.

Films well agitated in the bath should be completely fixed in $1\frac{1}{2}$ minutes. Replace bath frequently as a partially exhausted bath is slow in fixing and its hardening properties are notably decreased. (Fixing, see p. 209.)

MULTI-SOLUTION TECHNIQUE

Multi-solution developer is made up of a range of concentrated stock solutions of good keeping quality, so that by simple measurement and without weighing, a whole selection of developers can be prepared easily and rapidly. This method has the advantage that when a particular developer is only wanted occasionally, or when one uses a range of developers such as a normal negative developer, a fine grain or a paper developer, one can prepare any or all

such developers quickly and safely from the same stock solutions. If one has a normal developer in frequent use it will be necessary to keep it ready made up, but even then it is of advantage to have a multi-solution set at hand, either to allow of the rapid preparation economically and quickly of a special developer or to use the stock solutions to modify the normal developer in some desired manner.

93.—METOL-HYDROQUINONE MULTI-SOLUTION DEVELOPER

(A) Metol Stock Solution

Sodium sulphite, anhyd.	...	...	40 grains	2 grams
Metol	...	...	40 grains	2 grams
Water to make	...	...	4 ounces	100 c.cm.

(B) Hydroquinone Stock Solution

Sodium sulphite, anhyd.	...	...	40 grains	2 grams
Hydroquinone	...	...	40 grains	2 grams
Water to make	...	...	4 ounces	100 c.cm.

(C) Sodium Sulphite Stock Solution

Sodium sulphite, anhyd.	...	...	3 ounce	20 grams
Water to make	...	...	4 ounces	100 c.cm.

(D) Sodium Carbonate Stock Solution

Sodium Carbonate	...	...	400 grains	20 grams
Water to make	...	...	4 ounces	100 c.cm.

(E) Potassium Bromide Stock Solution

Potassium bromide	...	...	200 grains	10 grams
Water to make	...	...	4 ounces	100 c.cm.

(F) Borax Stock Solution

Borax	...	...	100 grains	5 grams
Water to make	...	...	4 ounces	100 c.cm.

The preparation of a developer with the aid of these stock solutions is shown by an example using the *Focal Universal M-Q* developer **No. 7**. To produce a dish developer with a dilution of 1:5 we shall require the following quantities taken in the order given.

<i>Focal Universal M-Q</i> No 7.	Original Formula	Stock Solutions	Quantity for 600 c.cm.
Metol	3 grams	150 c.cm. (A)	15 c.cm.
Sodium Sulphite ...	75 grams	375 c.cm. (C)	37.5 c.cm.
Hydroquinone ...	11 grams	550 c.cm. (B)	55 c.cm.
Sodium carbonate ...	75 grams	375 c.cm. (D)	37.5 c.cm.
Potassium bromide ...	1 gram	10 c.cm. (E)	1 c.cm.
Water to make ...	6,000 c.cm.	6,000 c.cm.	600 c.cm.

Note that in each case the total volume of water is

given and not the amount which must be added to reach the required volume. In the case of the third column of figures, for example, the total volume of the necessary stock solutions is 146 c.cm. We shall therefore require to add a further 454 c.cm. of water to bring the volume to 600 c.cm.

It will be seen that the developer compounded from the stock solutions is not quite identical with the original formula inasmuch as the stock solutions A and B each contain a certain amount of sodium sulphite as preservatives. The increase in the total sulphite content is not sufficient to call for any adjustment when the stock solution C is added.

From the example given it will prove a simple matter to make up other developer combinations using the multi-solution technique. There is just one precaution to bear in mind and that is not to overstep the saturation limit with the stock solution of any one constituent. (The saturation limit of all the chemicals can be obtained under the heading of "solubility" in the list on pages 286-291.)

RESTRAINED DEVELOPMENT

We have seen (p. 19) that in addition to the chemical reaction involved in the reduction of the silver bromide there are other processes taking place during development which can notably influence the result. The process of image formation is notably affected by the fact that in the heavily exposed areas the bromide set free during development acts as a strongly retarding agent on the growth of the image at those points. This naturally suggests that if we could control this particular process it could be used to modify the contrast of the negative. Actually such methods were published about 1900 and in recent years they have again been brought forward sometimes with somewhat extravagant claims as to their advantages.

One of the oldest of such processes by which the bromide

effect is utilised is that which the Germans called "Planliege" development, literally "flat lying development." This consists in having the carefully levelled negative lying sensitive face up in developer which is completely undisturbed. The perfectly horizontal position of the plate inhibits the diffusion or flow of the exhausted developer from the heavily exposed parts of the negative with the natural effect that development slows down in the high lights but proceeds normally in the shadows. This has never proved a popular process because of the trouble involved in the careful levelling of the plate, therefore simpler methods have been developed to attain the same effect.

These simpler methods make use of the principle of intermittent development and were introduced about the year 1911. If one takes a negative, plunges it into developer, then withdraws it and allows the adsorbed developer to work the following process takes place. In the high lights the energy of the developer is soon spent while in the shadows or lightly exposed areas the action of the developer proceeds with the general result that development of the high lights is held back but the shadow areas go on developing with very little diminished energy. This can be of *real advantage in the case of underexposed negatives or those of very contrasting subjects.*

This principle can be applied in various ways. One of the oldest methods is to place the negative in developer until reasonably saturated with the developer solution, then withdraw it and place in water, repeating the process until the desired effect or degree of development has been attained. In recent years this process has been investigated by A. Knapp who has suggested the following formula.

94.—AMIDOL DEVELOPER FOR INTERMITTENT DEVELOPMENT

Amidol ...	...	...	...	10 grains	0.5 gram
Sodium sulphite, anhyd.	...	...	...	40 grains	2 grams
Water ...	...	...	...	4 ounces	100 c.cm.

The negative is given three soakings in the developer for

40 then 50 and finally 90 seconds respectively and after each immersion in the developer is allowed to lie in water for two minutes without being disturbed.

More energetic and more concentrated developers may be successfully used but no hydroquinone developer is suitable.

H. C. McKay has proposed the following metol formula:

95.—METOL DEVELOPER FOR INTERMITTENT DEVELOPMENT

Metol	...	...	...	...	...	$\frac{1}{2}$ ounce	15 grams
Sodium sulphite, anhyd.	...	...	...	...	...	2 ounces	60 grams
Caustic soda	...	...	...	...	...	90 grains	6 grams
Sodium carbonate	...	...	...	...	...	90 grains	6 grams
Borax	...	...	...	...	...	1 ounce	30 grams
Water to make	...	...	...	...	...	32 ounces	1,000 c.cm.

Another method of intermittent development consists in taking the developer saturated negative and pressing the gelatine face into close contact with a glass plate and then leaving the two plates in water at a temperature of 70°F. (24-25°C.) until development is complete. This process has recently been re-introduced under the name *P. & H. process* and a special film ribbon has been provided to allow of the development of roll films by the process.

The Metol developer, formula 92, is suitable for this *P. & H. process*, the negative being given an immersion ranging from 70 to 140 seconds according to the contrast of the subject and the properties of the film used. The greater the contrast the shorter the time the film should remain in the developer. Allow the film 15 minutes in the water.

Whilst intermittent development can provide the desired adjustment of contrast it would be quite wrong to think that there are no other methods of attaining a similar result. The method makes use of concentrated developer and hence there is a notable difference as compared to the result obtainable with normal developers. *If one uses a soft compensating fine-grain developer almost the same result can be obtained as by the intermittent method, with the added advan-*

tage of consistent fine grain. Hence the practical value of intermittent development is not yet fully proven.

REVERSAL DEVELOPMENT

The purpose of reversal development is the opposite of that of normal development in which from an exposed plate or film we obtain a negative, or if we are printing from a negative we get a positive. With reversal development there are two stages which result in our *obtaining a positive direct from an exposed plate or film*, or a negative from a negative and a positive from a positive by contact or enlarging methods of reproduction.

The process is of particular importance in the handling of *sub-standard cine-film and 35 mm. film for miniature cameras* and finds wide application in many processes of *colour photography*. In cases where the amateur requires only a *single copy* of an exposure, reversal development will supply him with a transparency which can be visually examined or projected in a small projector. The process is also useful in the preparation of *duplicate negatives*.

Reversal development is not a simple process and does not permit of any universally applicable formula being used, as its successful application depends to so large an extent on the nature of the sensitive *emulsion being used*.

The difficulties that may arise can best be dealt with by making a detailed study of the processes which comprise reversal development (see page 193). They consist of the following steps.

(1) The exposed material, plate or film, is first developed with a developer which will ensure that every exposed grain in the emulsion is developed. This is the *primary development*.

(2) The Image so developed is next *dissolved* completely away with a suitable *silver solvent*.

(3) The silver bromide remaining, that is the *silver*



CORRECT DEVELOPMENT—PERFECT GRADATION

The obtaining of a picture, that from the deepest shadows right through to the high lights reproduces a correct and natural scale of contrast, is in the first case a question of the right choice of sensitive material (see page 20). The correct choice of negative material can, however, be completely nullified by inappropriate development and in this connection the formula used and the method of development can exercise a tremendous influence on the result. Only when negative material and development are perfectly suited to one another can a correctly-developed picture with perfect contrast, such as is shown in our illustration, be produced.—*Hugo van Wadenoyen.*

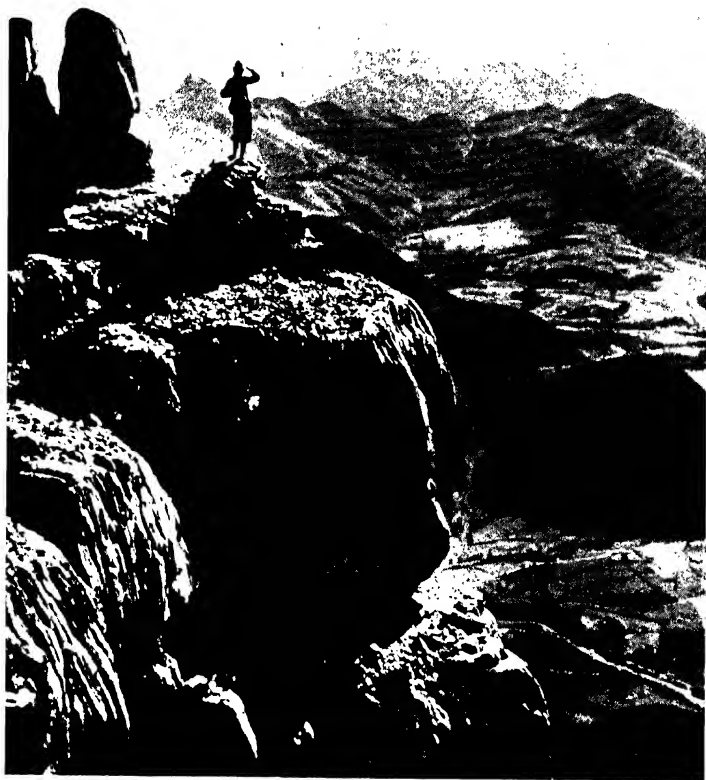




DIFFERENT PICTURES—SAME DEVELOPMENT PROBLEM

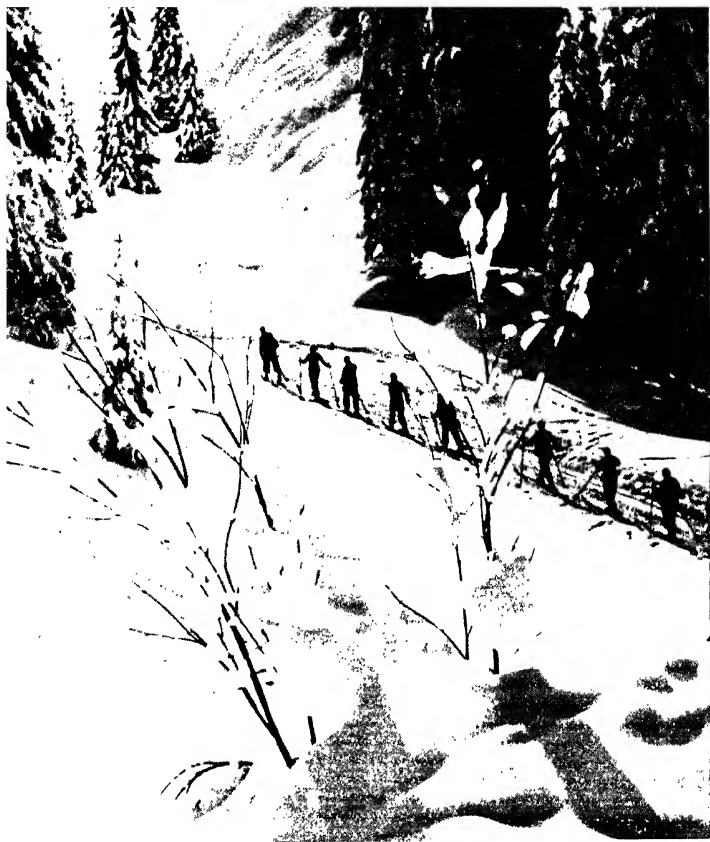
The appeal of the picture on the *left* lies in the brilliant lighting and the contrast between light and shade, whereas in the picture *above* it is the delicate tone values which provide the attraction and reproduce the atmosphere of a rainy morning in early spring. In both cases the production of too hard a negative had to be avoided.

In the picture *opposite*, taken against the light, a contrasty developer would have produced deep shadows devoid of detail and chalky high lights. A soft-working compensating fine-grain developer (see page 144) is the correct formula to use in such a case. Such a developer is also suitable for the picture *above* so long as the negative material permits it and the necessary adjustment in exposure has been made. Otherwise a somewhat more energetic but still soft-working developer such as Metol (see page 127) should be used or a diluted para-aminophenol (see page 133) developer.—Hugo van Wadenoyen and G. Schuh.



AVOIDING EXCESSIVE CONTRAST

This has been achieved in the pictures *above and opposite* by the use of an appropriate developer. A brilliant-working developer such as the Focal Universal M.Q. Developer 7 (page 129) would here have been a mistake, for it would probably have resulted in loss of detail in the distance and in the snow appearing like marble instead of appearing translucent. The developer which obviates both these possibilities is the Focal Fine-grain Developer (page 148). For examples like that on page 183 one would choose a particularly delicate-working modification of this particular developer (see page 148).—W. Remmel and P. Wolff.



AVOIDING HALATION

As explained on page 49, the avoidance of halation is not merely a question of sensitive material, but even more a matter of correct development. One must choose a surface developer, for example a fine-grain compensating developer (see page 144) or a tanning developer (see page 158). In the picture on page 186 halation is hardly perceptible, but in that on page 187 very characteristic and marked halation is seen in the street lamps. In neither of these cases was the development exactly right, but in neither case is the result unnatural.—G. Schuh and P. Damm.

MANAN'S
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&
ITE
WHISKY
JANUARY 1971

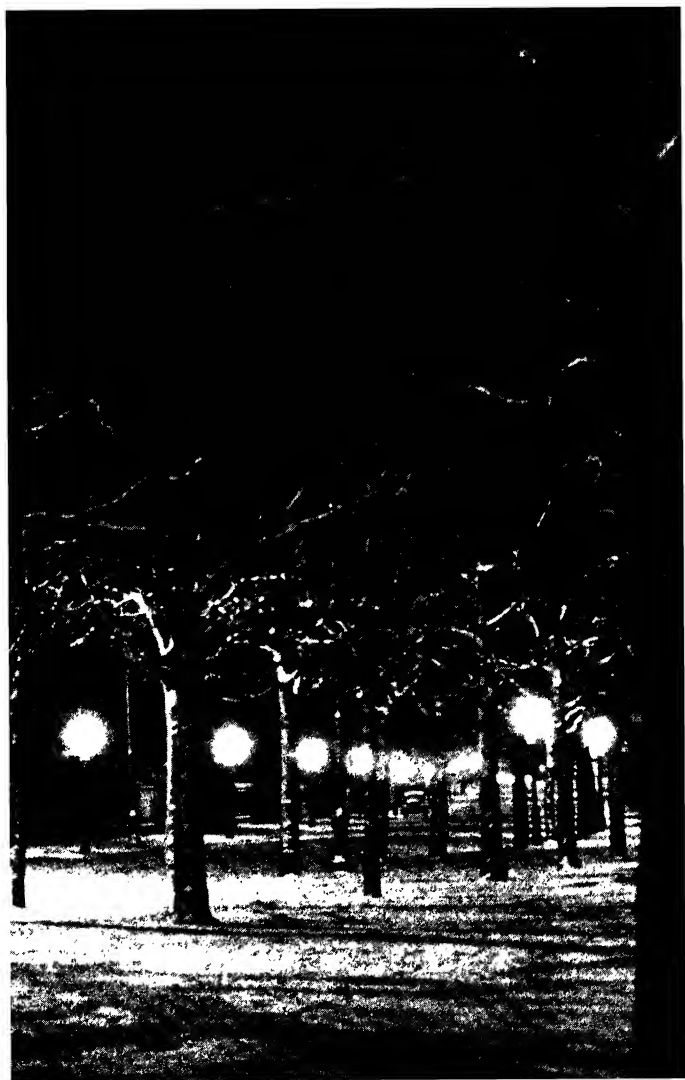
THE ONE WITH THE GREATEST CHANCE
OF WINNING
BUTLERS PRIZE
LOCKED HIRSHMAN'S
BIRD CHICK & BIRD
MADE BOTTLES OF COOL
MORRIS
STEVE

GAMING'S TIME

THE ONE WITH THE
GREATEST CHANCE
OF WINNING
BUTLERS PRIZE
LOCKED HIRSHMAN'S
BIRD CHICK & BIRD
MADE BOTTLES OF COOL
MORRIS
STEVE

ALAS

ALAS





THE DEVELOPMENT OF PORTRAITS

Portrait negatives require very special care in development if the fine shadows and details in the flesh tones are not to be lost; moreover, that possibility is often increased by the photographer choosing somewhat strong lighting in order to obtain increased effect (*opposite*). Hence in developing portrait negatives the whole endeavour must be directed towards obviating contrast and obtaining modelling and detail as well in the deepest shadows as in the high lights. Many professionals hold the view that this can only be obtained by the use of a Pyro developer (see page 132), while others favour a diluted paraminophenol (see page 133). Fine-grain developers are obviously applicable, but choice should be made of a formula which is not too soft-working, such as the borax M.Q. developer (see page 144) or the Focal Fine-grain Developer 46, Type No. 2. (see page 148)—E. Hoinkis and Alexander.





AGAINST THE LIGHT

The development of examples such as that *above*, where very strong light effects are present, is the same as for night photographs (page 186). In such a case as that above the tanning developer No. 70 (page 159) is particularly suitable. Silhouettes (*opposite*) call for a pronouncedly contrasty or hard-working developer such as the M.Q. contrast developer No. 31 (page 139) or the undiluted Focal Universal M.Q. Developer 7 (page 129).—J. Dulovits and Hugo van Wadenoyen.



COMMERCIAL PHOTOGRAPHS

With pictures as that on the *next page* it is essential that the subject be shown in good contrast with every detail clear and unmistakable and that the nature of the material composing the articles should be revealed. For this a brilliant working developer must be chosen such as the Focal Universal M.Q. 7 (page 129), used at a dilution of 1 : 3 to 1 : 5.—H. Gorny.



bromide not affected by the first exposure, is now fully exposed and developed and so provides the final image; this is the secondary development.

It will be clear that the nature and quality of this final image will be determined by the *quantity and structure of the silver bromide left behind* after the removal of the primary silver image.

If that *primary image* was a *dense* one, extending well into the emulsion layer, then the silver bromide remaining after its removal would be comparatively thin, and the *secondary image* produced by its exposure and the secondary development would naturally be *thin* also.

If, on the contrary, the *primary image* was *thin*, then a large quantity of silver bromide would remain and would produce a dense and probably *plugged-up image* on secondary development.

If a successful result is to be obtained by the reversal process, it is obvious that a nice *balance* must be observed between the image produced by the first exposure and the quantity of silver bromide which will remain when the primary image is removed.

It must be noted therefore:

(1) That the primary exposure will largely determine the density and the proportion of the emulsion forming the first image, and therefore the density and quality of the second or final image. Thus there is *no room for either over- or under-exposure* and therefore latitude in exposure when using the reversal process is small.

(2) The development of the primary image will have a great influence on the result. Such development must be complete, and so a strong-working, energetic developer is used and development time is such that there shall be no doubt that *full development* has been attained. To further this end it is usual to employ a *silver bromide solvent* in the primary developer, such as *ammonia* or *potassium sulpho-*

cyanide, which assists in the development and helps to reduce the amount of silver bromide which is left to form the secondary image.

(3) When the primary development is complete the image so developed is dissolved away in what is usually called the *reversal bath*. After a wash the remaining silver bromide is fully exposed to white light and completely developed in a *normal developer*.

Finally it may be noted that sensitive materials intended to be used in reversal processes are *specially coated* for the purpose, and the emulsion is usually *thinner* than is the case with ordinary films.

In the various formulae which follow, examples of most of the practical variations in reversal procedure will be given, but it must be emphasised that for any particular reversal film the maker's instructions should be adhered to, as they have been carefully worked out for that particular film.

Formulae for Dufaycolor Film

96.—PRIMARY DEVELOPERS.

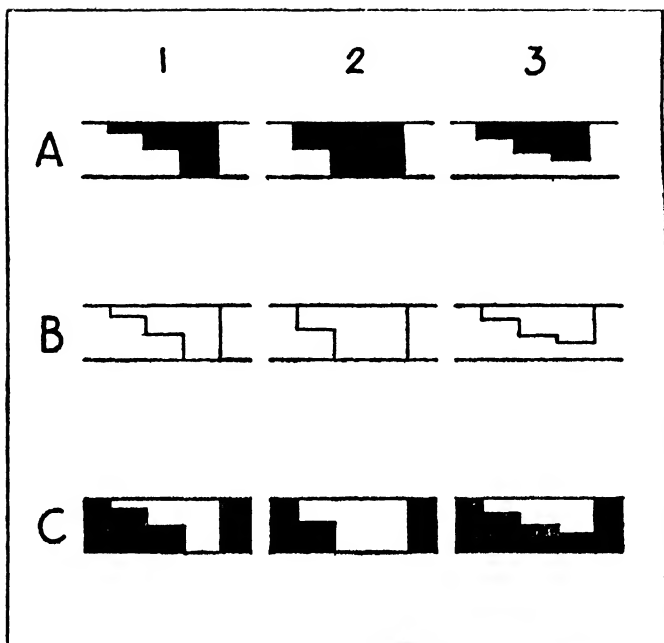
	Developer A		Developer B.	
Metol	60 grains	3 grams	130 grains	6.5 grams
Sodium sulphite cryst.	4 ounces	100 grams	4 ounces	100 grams
Hydroquinone ...	120 grains	6 grams	40 grains	2 grams
Potassium bromide	56 grains	2.75 grams	56 grains	2.75 grams
Ammonia, 880° ...	3 drams	11 c.cm.	—	—
Sodium carbonate cryst.	—	—	4 ounces	100 grams
Potassium sulpho- cyanide	—	—	180 grains	9 grams
Water to make ...	40 ounces	1,000 c.cm.	40 ounces	1,000 c.cm.

Development time is 3 *minutes* at 65°F. (18°C.) for developer A or 5 *minutes* with developer B. Note that developer B has somewhat better keeping properties than A.

The developed film is given a short wash, then reversed :

97.—REVERSAL BATH

Potassium permanganate	...	...	40 grains	2 grams
Sulphuric acid conc.	...	...	3 drams	10 c.cm.
Water	...	...	40 ounces	1,000 c.cm.



THE PROCESS OF REVERSAL DEVELOPMENT

Reversal development involves three distinct stages. A. Primary development in which the exposed material is developed with an energetic developer to a normal negative. The diagram shows a section through the three parts of the negative, shadows, middle tones and high lights. B. The dissolving of the primarily-developed silver. Solution is effected by a suitable silver solvent, leaving behind the unexposed silver bromide, which will go to form the positive image. C. This unexposed silver bromide is now exposed to light and developed to form the actual positive.

Column 1, on the left, shows the reversal development of a well exposed picture. Column 2, in the centre, shows the reversal of an over-exposed picture, the middle tones of which are being lost. Column 3, on the right, shows the reversal of an under-exposed picture. The lights of this under-exposed picture will remain partly undeveloped in stage A, leaving too much silver bromide undissolved in stage B, which exposed in stage C leads to much density in the lights.

When the film has been in this bath for 30 seconds white light can be turned on; bleaching generally requires from 3 to 5 minutes. The film is given a good rinse and cleared in the following clearing bath.

98.—CLEARING BATH

Potassium metabisulphite	...	...	1 ounce	25 grams
Water	...	...	40 ounces	1,000 c.cm.

This removes the brown stain produced in the reversal bath and allows the operator to make sure bleaching has been complete. When this is assured the film is given a wash, exposed to a 100-watt lamp at a distance of one foot for about a minute, moving the film to ensure even exposure, and the film is then given the second development in any normal developer, or in the A or B developer used for the first development.

Finally the film is fixed in a plain hypo bath (page 211), washed and dried.

Formulae for Gevaert Reversal Film

99.—PRIMARY DEVELOPER

Metol	...	...	...	40 grains	2 grams
Hydroquinone	...	...	...	160 grains	8 grams
Sodium sulphite, anhyd.	...	...	...	2 ounces	50 grams
Sodium carbonate, anhyd.	...	...	...	2½ ounces	60 grams
Potassium bromide	...	...	...	100 grains	5 grams
Potassium sulphocyanide	...	...	...	100 grains	5 grams
Water to make	...	...	...	40 ounces	1,000 c.cm.

Development time 5-9 minutes. Then wash for 5 minutes.

100.—REVERSAL BATH

Potassium dichromate	...	...	...	1½ ounces	30 grams
Sulphuric acid conc.	...	...	...	1½ ounces	33 c.cm.
Water up to	...	...	...	40 ounces	1,000 c.cm.

For use dilute 1 part with 5 parts water. White light may be used after 2 minutes in the reversal bath. Reversal requires 5 minutes, then wash. Clear with:

101.—CLEARING BATH

10% solution of sodium sulphite

After clearing give a further wash for 5 minutes.

102.—SECOND DEVELOPER

Metol	...	...	...	40 grains	2 grams
Hydroquinone	...	...	...	80 grains	4 grams
Sodium sulphite, anhyd.	...	...	...	2½ ounces	60 grams
Sodium carbonate, anhyd.	...	...	...	1½ ounces	40 grams
Potassium bromide	...	...	...	20 grains	1 gram
Water up to	...	...	...	40 ounces	1,000 c.cm.

After development rinse, fix in a plain hypo fixing bath (page 211) and then wash well.

Formulae for Pathe Reversal Film

103.—PRIMARY DEVELOPER

Sodium sulphite, anhyd.	...	...	...	1 ounce	20 grams
Paraphenylenediamine	...	...	...	½ ounce	10 grams
Potassium bromide	...	...	...	80 grains	4 grams
Water	...	...	...	40 ounces	1,000 c.cm.
Then add caustic soda	...	...	...	160 grains	8 grams

Develop for from 7-10 minutes, then wash and reverse.

104.—REVERSAL BATH

Potassium dichromate	...	...	...	100 grains	5 grams
Water	...	...	...	40 ounces	1,000 c.cm.
Sulphuric acid conc.	...	...	...	3 drams	10 c.cm.

After reversal rinse well and clear:

105.—CLEARING BATH

Sodium sulphite	...	...	...	1 ounce	25 grams
Water	...	...	...	40 ounces	1,000 c.cm.
Then add caustic soda	...	...	...	10 grains	0.5 gram

Clear for 2-3 minutes and again wash and develop.

106.—SECOND DEVELOPER

Metol	...	...	...	40 grains	2 grams
Hydroquinone	...	...	...	200 grains	10 grams
Sodium sulphite, anhyd.	...	...	...	3 ounces	75 grams
Potassium carbonate	...	...	...	1 ounce	25 grams
Potassium bromide	...	...	...	40 grains	2 grams
Water to make	...	...	...	40 ounces	1,000 c.cm.

When the second development is complete, the film is

fixed in a plain or acid fixing bath (page 211) and well washed.

The above series of formulae may be taken as typical of those used in reversal processes. Each separate operation must be carried to completion; this is particularly important in the reversal or bleaching.

If inspection shows that any trace of the primary developed image remains, the film must be returned to the reversal bath until it is completely bleached.

It is equally important that the times indicated for each successive treatment be carefully observed, and it will be noted that they vary with the different materials.

The formulae prescribed for one material are not usually as successful with other materials; the one bath which is transposable is the *bleaching bath*.

ELECTROLYTIC DEVELOPMENT

The idea that electrolytic processes, which play so large a part in technology to-day, might be of service in photography is not new, yet so far no really practical method has been evolved although some interesting investigations have been carried out.

J. Rzymkowski has published recently a reproduction of an electrically-developed portrait, but did not disclose the composition of the developer solution. He used a cylindrical battery jar with a resistance between it and the electric light supply. In the battery jar a porous cell separated the anode from the cathode. The anode consisted of a metal plate, while the cathode was of cylindrical form and of punched metal. The film was placed round the wall of the battery jar. The time of development was given as 15 minutes with a current strength of $\frac{1}{4}$ -ampere.

Another method which dispenses with electric current, but may be claimed as electrolytic, is that of R. S. Morse, who bathes the exposed material in the following bath and then places it in intimate contact with a copper plate.

107.—FORE BATH FOR ELECTROLYTIC DEVELOPMENT

Ammonia	...	...	...	...	1½ ounces	40 c.cm.
Formaldehyde	...	...	...	...	85 minims	5 c.cm.
Mercuric chloride	...	...	...	...	10 grains	0.5 gram
Water	...	...	...	...	8 ounces	200 c.cm.

CHOOSING THE DEVELOPER

The preceding survey of developers was based on a classification according to their mode of application (see p. 127). The number of formulae thus listed is, however, so large that it seems useful to provide a simplified summing up for the benefit of those who desire to choose a developer to suit one particular task or more.

Further details of the particular properties of the above developers will be found with the formulae and in the table of the "Characteristics of Developer Substances" which is given on pages 80-81.

XXVII.—THE CHOICE OF DEVELOPERS

Dish Developers

- | | |
|---|--|
| (1) <i>For universal use.</i> | M-Q 7 and para-aminophenol 17 |
| (2) <i>For strong contrast. Process, technical and scientific work.</i> | Metol with excess hydroquinone 30. |
| (3) <i>For extreme contrast. Process work.</i> | Caustic alkali hydroquinone 28. |
| (4) <i>Soft working.</i> | Metol I and/or pyro 13. |
| (5) <i>Compensating developer for against the light pictures.</i> | Pyrocatechin with little sulphite 70. |
| (6) <i>High speed development.</i> | Focal maximum energy developer 86. |
| (7) <i>Tropical developer.</i> | Metol with sulphite 31. Kodak tropical developer 78. |

Tank Developers

- | | |
|--|--|
| (8) <i>For universal use (not fine grain).</i> | Metol-hydroquinone 26. |
| (9) <i>For universal use, normal fine-grain development.</i> | Borax metol-hydroquinone with high sulphite content 32. Buffered borax metol hydroquinone 41. |
| (10) <i>For super-fine grain development.</i> | Metol-hydroquinone with sulphocyanide 46. Paraphenylenediamine 52. Orthophenylenediamine 57. Meritol 60. Super Degrainol 61. Kodak D25 62. |

THE NEED FOR BASIC FORMULAE

The photographer has the choice between a truly formidable collection of developer formulae. We have made every effort to arrange them according to their properties and their modes of application. It should therefore not be unduly difficult to choose the right developer for any job, were it not that the photographer is confronted in addition to the developers listed here by such a host of variants published elsewhere.

Unfortunately, through the publication of curves and data for every single recipe or formula the impression is strengthened that essential differences do exist between all of them, that the results published in such detail are veritably a scientific contribution and the outcome of careful investigation, aimed seriously to benefit the practical worker and advance the quality of his products by progressively improved chemical tools for which his highest regard is duly expected. In fact on more close scrutiny we find behind the overawing quantitative specifications an endless repetition of old formulae sometimes slightly altered or containing unimportant additions, old formulae named and coded in a manner which suggest a new formula and seem to claim credit for original authorship.

Let us for example investigate the most popular M-Q developers (p. 201) in order to see whether it would be possible to arrive at some basic types which could be generally adopted by those who are responsible for their publications.

There appears a series of M-Q dish and tank formulae, all are calculated for the same volume, namely, 1 litre of ready-for-use solution and confined to the basic ingredients, so that comparison is facilitated (Table **XXIX** offers a survey of an even fuller range of manufacturers' M-Q formulae so far not mentioned and now quoted complete with dilution data and time of development recommended). At first glance one notes that dish developers 1, 2 and 3 are

identical as also are tank developers 7 and 8. It is also perceptible that there is a close relation between the first three dish developers and the first two tank developers, that the only true difference is in concentrations and that by diluting the dish developer one can produce the tank developers which are exactly half the strength of the dish developers.

XXVIII.—M-Q DEVELOPERS COMPARED

		<i>Metol</i>	<i>Hydro-quinone</i>	<i>Sodium Sulphite</i>	<i>Sodium Carbonate</i>	<i>Potassium Bromide</i>
<i>Dish Developers</i>						
1. KODAK (U.S.)...	D61A	1.5	3	45	6	0.85
2. DEFENDER ...	3D	1.5	3	45	6	0.85
3. AGFA ...	47	1.5	3	45	6	0.85
4. AGFA ...	40	1.5	2.5	18	18	1.0
5. ILFORD ...	I-D2	0.65	2.6	20	12	0.65
6. FOCAL ...	No. 7	0.5	2	12	12	0.15
<i>Tank Developers</i>						
7. KODAK (U.S.)...	D61A	0.75	1.5	22.5	3	0.4
8. DEFENDER ...	3D	0.8	1.5	22.5	3	0.4
9. AGFA ...	42	0.8	1.2	45	8	1.5
10. ILFORD ...	I-D2	0.3	1.3	10	6	0.3
11. FOCAL ...	No. 26	1.0	2	18	6	2
<i>Fine-Grain Developers</i>						
12. KODAK (U.S.)...	D76	2	5	100	2	—
13. ILFORD ...	I-0.11	2	5	100	2	—
14. DEFENDER ...	6-D	2	5	98	2	—
15. AGFA ...	17	1.5	3	80	3	0.5
16. DEFENDER ...	4D	2.5	3	75	5	—
17. DUPONT ...	ND2	2.5	3	75	5	—

Quantity of constituents is given in grams per litre (parts per 1000).

In these formulae, that is 1, 2, 3, 7 and 8, we would appear to have the foundation or type formula for our *Basic Normal M-Q Developer (for dish and tank)*. At least it is one that has been chosen as a typical M-Q normal developer for dish and tank by three very important manufacturers. There is no reason why, should they so desire it, each manufacturer should not give his own number or code

XXIX.—MANUFACTURERS

Formula	108 ANSCO 40 Tray	109 ANSCO 42 Tank	110 ANSCO 47 Tray Tank	111 ANSCO 47a R	112 ANSCO 48M Meta Borate Tank	113 ANSCO 48Ma R	114 ANSCO 61 Tray	115 ANSCO 64 Tropica
Metal ...	4.5	0.8	1.5	3	2	6.3	1	2.5
Sodium Sulph.	54	45	45	45	40	30	15	25
Hydroquinone	7.5	1.2	3	6	1.5	10	2	6.5
Sodium Carb.	45	6.5	5	10	—	—	12.5	12.5
Potassium Br.	3	1.5	0.8	—	0.5	—	1	1
Additions	—	Pot. meta- bi-sulphite 4	Sod. bi- sulphite 1	Sod. bi- sulphite 2	Sod. meta- borate 10	Sod. meta- borate 40	—	—
Dilution ...	1:2	—	Tank 1:1	—	—	—	—	—
Development time in mins.	4-5	15-20	Tank 14 Tray 6	—	6	—	5	5

The above quantities are to be taken as parts per thousand or grams per litre of water.

to the developer as has already occurred in the case of *Agfa 47*, *Defender 3D* and *Kodak (U.S.) D61A*.

Developers 4, 5 and 6 are fundamentally different from the previous three but among themselves do resemble one another. All three are of the rather hard working type, giving contrasty negatives. This is the result of the higher alkali content compared with sulphite. Also formula 4 has more alkali than 5 and has a somewhat higher bromide content ; thus the final effect of the two developers is practically the same. No. 6 developer contains notably less bromide and so develops in a shorter time to the same contrast.

For the average photographer the individual properties of these developers need not be further particularised. As long as they are designated under the title of *Basic-Contrast M-Q Developer (for dish or tank)*, thus clearly indicating the

FURTHER M-Q FORMULAE

116 ANSCO 90 Contrast Tray	117 DEFENDER 3-D Tray Tank	118 DEFENDER 3-DR R	119 DEFENDER 8D Rapid	120 DEFENDER 10D Contrast	121 ILFORD 1D34 Tank	122 ILFORD 1D34 R	123 ILFORD 1D2 Concentrated
5	3.1	0.75	1.5	—	0.6	3	2
40	90	22.5	22.5	15	10	19.5	75
6	5.9	1.5	6	16.5	3	3	8
33.5	11.5	30	34	50	9	19	37.5
3	1.7	0.35	1	2	0.3	—	2
—	Sod. bi- sulphite 2.1	Sod. bi-sulphite 0.5	—	Boric acid 30 Pot. Carbonate 50	Sod. bi- sulphite 2.5	Sod. bi-sulphite 4.5	—
—	Tray 1:1 Tank 1:3	—	—	—	—	—	Dish 1:2 Tank 1:5
5	Tray 5 Tank 11	—	2-3	10	15	—	Dish 1:2 Tank 1:2

R = Replenisher Solution.
Sulph. = Sulphite Anhyd.
Carb. = Carbonate Anhyd.
Br. = Bromide.

particular purpose and use of the developers, he will recognise them whose ever reference number or code they may carry.

A notable modification of the Basic Developer type is given in formula 9, that is *Agfa 42*, which provides a *Basic Soft M-Q Developer (for dish and tank)*.

Developer No. 11 hardly finds a place in our system since its most notable quality is an increased bromide content. It would most justly be designated as a *Basic-Contrast M-Q Developer With Increased Bromide Content (for dish or tank)*.

This formula No. 11 can be taken as indicating that our system should not be too rigid but rather elastic in character. For example should a particular manufacturer consider that his film called for a developer with a somewhat enhanced bromide content then instead of calling for or substituting a special formula he can take the suitable Basic Formula and

use it with an increased bromide content, noting the fact by adding the corresponding supplementary title ("With Increased Bromide"). If need be the actual amount of increase can be specified, e.g. "*Basic-Contrast M-Q Developer, With Double Bromide Content.*"

There is also a real want for revision and agreement in the matter of fine grain developers. Very many fine grain developers are identical, for example formulae 12, 13 and 14. Formula 15 shows an unimportant modification of 12-14 while numbers 16 and 17 are somewhat less fine grain developers than the others and form a little group of two identical formulae put forward by two different firms under two different names.

Here again as in the previous table, it is seen that there are two groups of developers. Numbers 11-15 can be designated *Basic Normal Fine Grain Developers* and numbers 16 and 17 called *Basic Contrast Fine Grain Developers*.

For fine grain developers so many variations have been proposed, useful as well as useless, that the application of any simple system of designation is by no means easy to arrive at. At a first principle one would have to decide whether an alteration of or addition to a formula had any real purpose or result. The substitution of borax for example in place of other alkalies has often no real influence on the photographic properties of the developer other than to increase the time necessary to reach a certain density or gamma. Such differences or variations are best indicated and explained by comparison with a basic formula.

It is sincerely to be desired that authors and manufacturers of developers use the same system of indication or nomenclature. This would render the choice and right application of developers so much easier for the photographer, increase his understanding in the way they work and this in turn would help him to adjust his developer in special cases where, for example, increase of bromide or other variations are needed.

DESENSITISING

Desensitising is a process which so *reduces the light sensitivity* of plates and films as to allow of their being developed in comparatively bright yellow light.

We owe the process to Dr. Luppó Cramer, and it is not only one of the most interesting of photochemical effects, but is of the greatest practical importance in that it allows of *panchromatic* and other highly colour-sensitive material being handled under conditions which permit of the closest possible control.

Desensitising substances must not only have the power to reduce or almost to destroy the light sensitivity of silver bromide, but must do so without in any way *affecting the latent image* and without exerting any deleterious effect on the developer. Many such substances have been discovered, but only a few have received practical application.

Phenosafranin

This was the first desensitiser to be used to any great extent, and appears on the market under the names *pinasafrol* and *desensitol*. It is a useful desensitiser but has one drawback: it *stains* films and fingers. Nevertheless it is widely used for it is cheap, works well and is compatible with most developers.

An exception is *hydroquinone*, the action of which is accelerated. With normal M-Q developers there is little perceptible effect so long as the concentration of pheno-safranin is low.

Desensitisers can be used in two ways, either as a *fore-bath* or *added to the actual developer*. Of these two methods the fore-bath is always preferable for a number of reasons, and should be employed whenever possible. Some of the desensitisers are precipitated by certain constituents in

developers and can cause troublesome flecks and spots of colour on negatives and thus should not be used in the developer.

Desensitisers are best kept in the form of a stock solution which can be diluted when required to prepare the fore-bath.

124.—PHENOSAFRANIN DESENSITISER

Phenosafranin	...	...	...	...	...	...	1 part
Water	...	...	...	...	...	...	1,000 parts.

When the fore-bath is required, one part of the stock solution is diluted with 10 parts of water, thus giving a bath of 1 : 10,000.

The bath can be used for several negatives, but should not be kept too long as moulds tend to grow on it.

When used in the developer the desensitiser should have approximately the same strength as in the fore-bath, hence for each 40 ounces of developer (1,000 c.cm.), 2 ounces (50 c.cm.) of the stock solution will be used.

When the plate or film has been about *one minute* in the fore-bath or the developer, the *yellow safelight* can be turned on in the dark-room. This should be safe for all sensitive material, but if very highly *red sensitive panchromatic material* is being developed, then a somewhat *darker yellow-green safelight* may be preferable.

Basic scarlet N is another desensitiser, consisting of a mixture of *phenosafranin* and *chrysoidine*, the latter being a brown dyestuff. Its properties are similar to those of phenosafranin, except that it must only be used as a fore-bath. The following formula has been devised by B. T. Denne, which reproduces the properties of basic scarlet.

125.—DESENSITISER (B. T. DENNE)

Chrysoidine	...	...	...	20 grains	1 gram
Phenosafranin	...	...	...	20 grains	1 gram
Distilled water	...	...	...	4 ounces	200 c.cm.
Alcohol	...	...	...	1½ drams	5 c.cm.

For use, one part of the stock solution is diluted with 50 parts of water.

Pinacryptol Green and Pinacryptol Yellow

The disadvantage of the strong staining properties of phenosafranin and its allied compounds soon led to the discovery of other desensitisers which did *not stain* to the same extent.

Pinacryptol green was the first to receive wide application. In solution it has a dark-green colour, but its *staining properties are weak* and the slight coloration of the film resulting from its use disappears entirely on washing.

Pinacryptol yellow has only a pale yellow colour in solution and *does not stain at all*. For use, it is dissolved 1 : 2,000 in water.

Both these desensitisers must be used as a fore-bath and not in the developer solution. Pinacryptol green is precipitated by many developers and pinacryptol yellow is decomposed by *sulphites*. Hence they should only be used in a fore-bath. Their use may slightly influence the time of development by lengthening it, but in general this is not noticeable.

126.—PINACRYPTOL DESENSITISER

Pinacryptol green	...	...	...	24 grains	1 gram
Water	...	...	...	20 ounces	500 c.cm.

To prepare the bath, 1 part of the above stock solution is diluted with 9 parts of water, giving a bath of 1 : 5,000 of the actual desensitiser.

The material to be desensitised is given *two minutes* in the fore-bath, then the light safelight can be turned on, the plate or film quickly rinsed and placed in the developer.

The latest of the pinacryptol series of desensitisers is *pinacryptol white*, which is colourless and has the advantage that it can be used in any developer if so desired, as no precipitation occurs nor is it decomposed by the solutions. It appears on the market in the form of small tablets.

127.—PINACRYPTOL WHITE DESENSITISER

1 tablet to be dissolved in warm water	...	1 ounce	25 c.cm.
--	-----	---------	----------

When dissolved the solution is allowed to cool and is then sufficient to add to 20 ounces (500 c.cm.) of developer.

Ilford Colourless Desensitisers

Qualitol. This is sold in the form of a clear colourless solution which is diluted with 20 parts of water for use.

Plates or films are bathed in the dilute solution for two minutes and then passed into the developer without rinsing.

Development can be observed by using an Ilford Bright Green Safelight in which a 15-watt lamp provides light. The dark-room lamp should be some 6-8 feet away from the developer dish or tank.

Desensitising Yellow is sold in 1 gram tubes (15½ grains). The contents of a tube, a fine yellow powder, are dissolved in 40 ounces (1 litre) of boiled water. When solution is complete the solution is made up to 80 ounces (2 litres) with cold water and is then ready for use. Bathe for two minutes and then proceed as described for Qualitol.

Various other Desensitisers

Johnson's Yellow Desensitiser. A non-staining desensitiser supplied in powder form. Contents of tube are dissolved in 20 ounces warm water and upon cooling may be used as a fore-bath without further dilution. Keeps well if stored in a brown bottle, away from bright light.

P.A.C. Desensit N. Does not stain, fog or affect the latent image. For use as a fore-bath, dilute the stock solution as supplied with four or more volumes of water and bathe the film 30-60 sec. It can also be added to the developer. For a fast pan emulsion add 20 c.cm. per litre. A bright green safelight may be turned on after 30-60 sec.

Caution: Fine-grain developers will not work satisfactorily with densitisers, which, therefore, should not be used with them.

FIXING

What the Process Is and How It Works

When we expose and develop a plate or film *only about 25 per cent of the silver bromide* in the emulsion is used up in forming the negative image. The balance, which has not undergone any change in the developer, must be *removed in the fixing bath* if we are to obtain a clear and permanent negative.

As a fixing agent *hypo* is used almost exclusively. To the chemist *hypo* is *sodium thiosulphate*, but the photographic world always calls it *hypo*.

Fixing is no simple process of solution like the dissolving of a lump of sugar in water ; it involves a series of reactions in which the silver bromide is converted first into an *insoluble salt*, then into a *more soluble salt* and finally into a *freely soluble salt* which water can wash away. These processes are of great practical importance and should be thoroughly understood by the photographer.

The first action of *hypo* on the silver bromide is to *convert it into silver thiosulphate*, a very difficultly soluble salt. At this stage in the process the salt is distributed through the film and cannot be removed by water. If the fixing process be stopped at this stage the film will have a milky appearance and the negative will not be permanent.

The further action of the fixing bath, due to the great excess of *hypo* which it contains, is to convert the silver thiosulphate into the more soluble double salt *silver-sodium-thiosulphate*, and further *hypo* produces the very easily soluble *silver-disodium-thiosulphate* which is completely removed by water.

This short summary of the fixing process shows how necessary it is to allow sufficient time for proper fixation if we are to obtain permanent negatives. A useful rough

rule is to allow at least *double the time that is required for the clearing of all trace of milkiness from the film*. Only by so doing can one ensure that no deleterious residue is left behind which later will affect the permanence of the negative.

Two points emerge from the consideration of the nature of the fixing process, first that a *sufficient excess of hypo must be present* in the bath in order to form the easily soluble double salt, and also that it is *not good policy to use too strong a bath*. From what has been said it will be clear that the disappearance of the milky silver bromide from the film is not necessarily evidence that the bath is working normally. Unless the necessary excess of hypo is there the soluble double salt cannot be formed and cannot therefore be dissolved out.

It may also just be mentioned that *economy in fixing baths does not pay* with hypo being as cheap as it is.

Between Rinse and Stop-Bath

Developers and fixing baths do not agree with one another, hence it is necessary to *remove as much as possible of the developer* from the negative before it is placed in the fixing bath. If this is not done, developer in the fixing bath can affect its working, shorten its life and give rise to a number of troubles. (See page 281.) In certain cases development may even continue in the fixing bath.

Hence the rinse between developing and fixing is not so unimportant as some people think. It should be *short but thorough*, and preferably in *running water*, or at least in water that is frequently *renewed*. There is no point in rinsing the negative in a bath which contains nearly as much developer as the developer bath itself.

Sometimes a stop-bath is used instead of or as an auxiliary to the rinse; this is a bath containing about 2 per cent of *acetic acid*. Here again care should be taken to ensure that the bath remains acid and is not completely neutralised by

the *alkali* from the developer. This is easily tested for by using *blue litmus paper*. So long as the litmus paper turns red immediately the bath is still acid.

Plain or Neutral Fixing Baths

Fixing baths consisting only of a solution of hypo in water can be used for the fixation of negatives, but only when great care is taken to ensure that no developer is carried over into the fixing bath. In certain positive processes the use of a plain fixing bath is essential, but for negative work it is the *exception and not the rule*.

It is sometimes said that the greater the content of hypo in a fixing bath the quicker it fixes. This is not so. The speed of fixation rises with the content of hypo up to a certain point; beyond that, speed of fixing falls with increasing hypo content. *The useful limit lies about 40 per cent of hypo*: with 50 per cent or more the speed of fixation falls to that of a solution containing only 5 per cent. The most generally useful concentration is from 25 to 30 per cent.

Acid Fixing Baths

The acid fixing bath is the most widely used in practice, for it promptly *neutralises any trace of alkali* brought over from the developer and *prevents stains* and other troubles that might otherwise arise from this source.

The acidifying of the bath cannot be achieved by the addition of any acid, as many of these substances would decompose the hypo and set free *sulphur*. Hence use is made of what are called *acid salts* for this purpose, of which the most widely used are *potassium metabisulphite* or *sodium bisulphite*.

Certain weak organic acids like *acetic acid* can also be used, but are always accompanied by a proportion of *sodium sulphite*.

128.—ACID FIXING BATH WITH BISULPHITE

Water	...	...	...	...	40 ounces	1,000 c.cm.
Hypo cryst.	...	...	...	...	10 ounces	250 grams
Potassium metabisulphite	...	...	...	...	1 ounce	20 grams
or Sodium bisulphite	...	...	...	...	$\frac{3}{4}$ ounce	15 grams
or Bisulphite lye	...	...	...	...	$1\frac{1}{2}$ ounces	40 grams

Although hypo is almost invariably used in crystal form, It does also appear in anhydrous form and is thus used for many packed fixing salts. It may therefore be of interest to note that *100 parts crystal hypo = 65 parts anhydrous.*

129.—ACETIC ACID-SULPHITE ACID FIXING BATH

Water	...	...	...	...	40 ounces	1,000 c.cm.
Hypo	...	...	...	...	10 ounces	250 grams

To this is added when the hypo is dissolved :

Water	...	...	...	...	3 ounces	75 c.cm.
Sodium sulphite	...	...	...	...	$\frac{1}{2}$ ounce	12.5 grams
Acetic acid	...	...	...	...	1 ounce	25 c.cm.

Caution: When making up acid fixing baths care should be taken not to add the acidifying solution to a warm hypo solution, also the addition should be made slowly and with constant stirring.

It should be noted that dissolving hypo in water always produces a notable lowering of temperature, hence it accelerates the process of solution if the water is warmed somewhat beforehand. Once made the solution should be allowed to regain room temperature before any other additions are made.

Bisulphites and Metabisulphites tend to lose sulphur dioxide when powdered, especially under warm conditions. This is a disadvantage when used for packed powdered fixing baths. *D. P. Woosley* and *K. G. A. Pankhurst*, have found that the alkali hydrogen sulphates, in particular sodium hydrogen sulphate, are stable, easily obtained, non-deliquescent free flowing crystals which can be packed in dry condition and are admirably adapted to making up both hardening and non-hardening fixing baths.

130.—ACID NON-HARDENING FIXING BATH WITH SODIUM HYDROGEN SULPHATE

Hypo, cryst.	14 ounces	350 grams
Sodium sulphite, anhyd.	300 grains	15 grams
Sodium hydrogen sulphate	300 grains	15 grams
Water to make	40 ounces	1,000 c.cm.

The hypo and the sulphite are dissolved in about 24 ounces (600 c.cm.) of water about 125°F. (50°C.) and the sodium hydrogen sulphate in about 6 ounces (150 c.cm.). Both solutions are cooled to 70°F. (21°C.) and the acid solution poured into the hypo solution with stirring. The total volume is then made up with cold water.

Hardening and Fixing Baths

The advantages of the hardening and fixing bath are not confined to work at high temperatures; they materially *reduce risk of injury to the sensitive film* whenever they are used.

The actual hardening agent is usually *chrome alum* or *potash alum*. Of these chrome alum exerts the greater hardening influence, but chrome alum baths have *poorer keeping properties* than those using potash alum. They lose their hardening properties rather quickly, whether the bath is in use or not. Hence many workers prefer to use the potash alum baths.

All hardening and fixing baths must contain a definite proportion of acid, otherwise alkali from the developer will decompose the hardening agent. Kodak have found that acetic acid may be supplemented with advantage by *boric acid* which increases the hardening, lengthens the life of the bath and notably inhibits the formation of a precipitate.

The following formula provides a useful stock solution:

131.—HARDENING STOCK SOLUTION

Water at 125°F. (52°C.)	$\frac{1}{2}$ gallon	2,500 c.cm.
Sodium sulphite, anhyd.	12 ounces	300 grams
Acetic acid 28%	38 ounces	950 c.cm.
Boric acid cryst.	6 ounces	150 grams
Potash alum	12 ounces	300 grams
Cold water to make	1 gallon	4,000 c.cm.

To prepare 28 per cent acetic acid dilute 3 parts glacial acetic acid with 8 parts of water. Use 1 volume of the hardening stock solution to 4 volumes of 30 per cent hypo, adding the stock solution to the hypo slowly and with continuous stirring.

Caution: On no account must an attempt be made to dissolve the hypo with the other constituents; the two solutions must always be made separately.

132.—HARDENING FIXING BATH WITH SODIUM HYDROGEN SULPHATE

Hypo cryst.	14 ounces	350 grams
Sodium sulphite, anhyd.	150 grains	7.5 grams
Sodium acetate	300 grains	15 grams
Boric acid	200 grains	10 grams
Sodium hydrogen sulphate	300 grains	15 grams
Potash Alum	200 grains	10 grams
Water to make	40 ounces	1,000 c.cm.

Dissolve the hypo, sulphite, acetate and boric acid in about 60% of the total water at about 125°F. (50°C.), in the order given. Cool solution to 70°F. (21°C.). Dissolve the sodium hydrogen sulphate and the alum in about 20% of the water at the same temperature as above and cool to 70°F. (21°C.). Then add the latter solution to the former stirring and make up to correct volume with cold water.

This formula may be packed in dry powder form as follows :

133.—PACKED FIXER IN DRY POWDER FORM

Packet A—Hypo anhyd.	Packet B—Sodium hydrogen sul-
Sodium sulphite anhyd.	phate
Sodium acetate	Alum
Boric acid	

Note that 9 ounces (223 grams) of anhydrous hypo are equal to 14 ounces (350 grams) of the crystal substance.

To make up the bath from such a packet, dissolve the contents of Packet A in about 24 ounces (600 c.cm.) of warm water and cool to 70°F. (21°C.). Next dissolve the contents of Packet B in about 8 ounces (200 c.cm.) of warm water,

cool to 70° F. (21 C.) and then pour the solution of B into the solution of A stirring constantly. Then make up to the correct volume with cold water.

Quick Fixing Baths

The time of fixing can be shortened by the addition of *ammonium chloride* to a plain or neutral fixing bath; the effect is particularly notable when the negative material contains *silver iodide*.

Quick fixing baths have the *disadvantage of a shorter life* than normal baths, and also that they have a *bad influence on the permanency of the negative*, which appears to be due to the formation of unstable *double salts*. Hence quick fixing baths should only be used when speed of fixation is of more importance than good keeping properties in the negative.

H. Parker and J. I. Crabtree give the following formula for a very quick-working fixing bath:

134.—QUICK FIXING BATH

Water	...	...	...	...	40 ounces	1,000 c.cm.
Hypo	...	...	.	...	14 ounces	350 grams
Ammonium chloride	...	...	...	...	1 ounce	25 grams

Life and Capacity of Fixing Baths

If permanent negatives, or prints either for that matter, are desired, it is very important that the fixing bath *should not be overworked*. It is impossible to control the condition of the fixing bath by mere visual examination, a fixing bath near exhaustion will still apparently clear the negative but the difficultly soluble silver salts will still remain in the film. Hence some other method must be used to ascertain whether the bath is approaching exhaustion or not.

The time required for fixing will give some indication. If it is noted that it takes *twice as long* to clear a plate or film as it did when the bath was fresh, it is being used up.

Then, too, one can remember that a 40-ounce (1 litre) bath will safely fix about 30 plates or films 10 × 8 inches,

that is, say, 2,400 square inches of plate or film. Other plate or film sizes will be in proportion.

XXX.—CAPACITY OF A FIXING BATH

Size of Negative	Number which can be fixed in 40 ounces (1 litre) of freshly made-up bath				
8 × 10 inches	30
8½ × 6½	„	(whole plate)	...	...	45
6½ × 4½	„	(½-plate)	...	...	90
4½ × 3½	„	(¼-plate) = 9 × 12 cm.	...	...	150
2½ × 3½	„	= 6 × 9 cm.	...	...	240
1½ × 2½	„	= 4 × 6.5 cm.	...	...	480
1½ × 1	„	= 24 × 36 mm.	...	...	1,400

Note that these figures should be taken as a safe maximum. In the case of roll films the number of negatives is given by multiplying the spools by the number of exposures, for example, 30 spools $2\frac{1}{4} \times 3\frac{1}{4}$ with 8 exposures will yield 240 negatives.

A useful test is to take about an ounce (25 c.cm.) of the bath, put into a test-tube or clean glass and add 3–4 drops of a 10 per cent solution of *potassium iodide*. If no cloudiness appears the bath is still fit for use; if the cloudiness disappears on shaking, the bath is becoming used up; but if a permanent precipitate is formed the bath is exhausted.

Another simpler test is to place a drop of the fixing bath on a clean filter paper, expose it to daylight and if a black stain develops round the edge of the spot the bath is exhausted.

In hardening and fixing baths the acidity must be watched; this is done by using *blue litmus paper*. If it does not at once change to red when dipped into the bath, a further quantity of the acid hardener stock solution must be added.

COMBINED FIXING AND DEVELOPING

The combining of development and fixation in one operation and in one and the same bath is an old problem

in photographic technique, to which a great deal of attention has been given without any perfectly satisfactory solution having been found. A developer which contains hypo must be so compounded that development takes place as quickly as possible, while the fixation is a distinctly slower process, hence it must comprise and combine a *rapid-working developer* and a *slow-working fixing bath*.

It is clear that such a process does not allow of any real control, and that in obtaining a very rapid development most of the important ends in development such as *good gradation, fine grain, etc.*, must be sacrificed. There is also the danger of fogging due to the reduction of *silver bromide* dissolved by the *hypo*, which can produce a strong *dichroic fog* (see page 280) on the negative. Hence the advantages of the combined method hardly appear great enough to overbalance the very obvious disadvantages.

If such a process is used the developing agents must be those whose developing properties are not destroyed by the presence of hypo, and which work reasonably well in a solution containing that substance. Such a developing fixing bath can be made using *pyrocatechin*.

135.—PYROCATECHIN DEVELOPING FIXING BATH

1.	Water	...	...	...	...	3 ounces	75 c.cm.
	Sodium sulphite, anhyd.	...	...	...	...	$\frac{3}{4}$ ounce	15 grams
	Caustic potash	...	...	...	...	140 grains	7 grams
	Pyrocatechin	...	...	...	...	140 grains	7 grams
2.	Water	...	...	...	...	10 ounces	250 c.cm.
	Hypo	...	...	...	...	2 ounces	50 grams

In normal cases take $\frac{1}{2}$ -ounce (12 c.cm.) of No. 1, $\frac{3}{4}$ -ounce (20 c.cm.) of No. 2, and 1 ounce (25 c.cm.) of water. The relative proportions of the two solutions to be used are actually dependent upon the character of the negative material, and the way in which it develops and fixes; for example, with an emulsion which fixes quickly and easily the proportion of solution 2 would require to be reduced.

Caution: The developer can only be used once.

Lumiere and Seyewetz put forward the following formula:

136.—AMIDOL DEVELOPING FIXING BATH

Amidol	...	...	...	...	100 grains	5 grams
Sodium sulphite, anhyd.	...	...	...	...	1½ ounces	40 grams
Trisodium phosphate	...	...	...	...	½ ounce	20 grams
Hypo	...	...	...	...	2 ounces	50 grams
Water to make	...	...	...	...	40 ounces	1,000 c.cm.

Time of development and fixing varies from 15–30 minutes.

According to *British Patent 459,908* the addition of grape sugar effects a decided improvement in the properties of developer-fixers, but actual tests do not show any appreciable improvement.

As a matter of interest the following formula, from the patent, is given:

137.—METOL-HYDROQUINONE DEVELOPING FIXING BATH

Metol	...	...	...	...	20 grains	1 gram
Hydroquinone	...	...	...	...	10 grains	0.5 gram
Sodium sulphite, anhyd.	...	...	...	...	70 grains	3.5 grams
Hypo	...	...	...	...	80 grains	4 grams
Caustic soda	...	...	...	...	40 grains	2 grams
Ammonia	...	...	...	...	17 minims	1 c.cm.
Grape sugar	...	...	...	...	60 grains	3 grams
Water	...	...	...	...	40 ounces	1,000 c.cm.

THE RECOVERY OF SILVER

Silver is a somewhat costly material, hence its recovery when it occurs in appreciable quantities in fixing baths and the like is worth while.

It will be remembered that only about 25 per cent of the silver in sensitive materials is usually used up in the developed image, hence the balance finds its way into the fixing bath. When large quantities of photographic materials are used, the amount of silver so accumulated is very appreciable and well worth recovery by one or other of the methods to be described.

Determining the Amount of Silver in Fixing Baths

The amount of silver which a fixing bath will contain depends naturally on the extent to which the bath is used. On an average a silver content of 2–3 parts per 1,000 can be reckoned on, but it may go as high as 1 part per 100.

In most cases people do not determine the silver present, they are satisfied to recover it; but if determination be required, the usual

analytical methods can be used although these are usually beyond the capacity of a dark-room staff.

Kodak have produced an *Argentometer* which is very simple to manipulate but distinctly expensive to purchase. It measures the depth of colour of a colloidal solution of silver sulphide by means of a photo-cell and so determines the amount of silver in the bath.

A modification of the process using visual comparison has been worked out by K. Kieser and comprises a colour comparison or matching process.

The following solutions are required:

138—TEST SOLUTIONS FOR DETERMINING SILVER

1. Water	...	...	...	...	40 ounces	1,000 c.cm.
Hypo	...	...	...	...	4 ounces	100 grams
Silver chloride	...	...	...	...	54 grains	2.7 grams
2. Citric acid	...	...	...	...	180 grains	9 grams
Sodium citrate	...	...	...	...	4 ounces	100 grams
Water to make	...	...	...	...	40 ounces	1,000 c.cm.
3. Gelatine	...	...	...	...	80 grains	4 grams
Water	...	...	...	...	40 ounces	1,000 c.cm.

Add a few drops of clove oil as preservative.

The gelatine is first swollen in cold water, then heated on the water bath with stirring until completely dissolved, and finally made up to the correct volume.

4. Sodium sulphide	...	...	...	...	$\frac{1}{2}$ ounce	12 grams
Sodium sulphite	...	...	...	...	$\frac{1}{4}$ ounce	6 grams
Water to	...	...	...	...	4 ounces	100 c.cm.

The standard solution for comparison is made by taking 4 c.cm. of solution (1) and adding 6 c.cm. of solution (2) and 10 c.cm. solution (3). The mixture is now diluted to nearly 100 c.cm. and 2 c.cm. of solution (4) added. This provides a brown colloidal solution of silver sulphide which keeps quite well in a well-corked vessel.

To determine the amount of silver in a fixing bath this standard solution, which contains exactly 2 grams of silver per litre, or 1 part in 500, is used. First take 4 c.cm. of the fixing bath, add the same amounts of solutions 2 and 3, namely 6 c.cm. of No. 2 and 10 c.cm. of No. 3, then add water to nearly 100 c.cm., add the 2 c.cm. of solution No. 4 and make up to exactly 100 c.cm.

If now equal volumes of these two solutions, that is, the standard and the one made from the fixing bath, are compared and are found to have identical shades of brown, they must contain the same quantity of silver, namely 2 grams per litre. If the solution from the fixing bath is a deeper brown, it contains more silver.

Then take half the volume, add an equal volume of water and shake well and compare again. If now the colour is equal, then the fixing bath contains twice as much silver as the standard, namely 4 grams per litre.

One or two trials will be sufficient to determine fairly exactly how much silver the bath does contain.

Naturally such a method is not necessary for the single worker, but it is useful in the small business where it is useful to know how much silver baths contain and therefore the amount which can be recovered from them.

Electrolytic Recovery of Silver

Where large volumes of fixing bath have to be dealt with this is the ideal method of silver recovery. It is clean-working and produces a very pure silver. The first cost of the apparatus is, however, heavy and this restricts the method to large businesses.

As an example of a *comparatively small installation*, that devised by H. Arens and J. Eggert may be mentioned. The cell itself of *glass or stoneware* has a capacity of 12 litres or approximately 3 gallons. Some 30 steel plates form the cathode with a total area of about 27 square feet (3 square metres). Either *carbon or silver plates* can also be used. The anodes are of carbon with about one-tenth the cathode surface. With a current of 0.8 ampere the whole of the silver is deposited in about 24 hours. If the speed of deposition is to be raised, then the *current strength* requires notable increase and the bath has to be warmed.*

Precipitation of Silver by Other Metals

Many metallic powders will precipitate silver from its solutions; the best results so far having been obtained by using *zinc dust*. It requires 3 parts of zinc dust to precipitate 1 part of silver; hence it is important to have some idea of the amount of silver present so as not to waste zinc.

The silver is precipitated in the form of a *black mud* which contains about 50 per cent metallic silver. *Under no circumstances* should the precipitation be carried out in the vessel used as a fixing bath. The best way is to accumulate sufficient spent fixing bath liquor and precipitate a large volume at a time. A simple test to determine if the silver is all thrown down consists in placing or hanging in the bath a small freshly-cleaned *strip of copper or brass*. If after a time the strip shows any trace of a *white deposit* of silver the precipitation has been incomplete.

When all the silver is thrown down it is allowed to settle, the supernatant liquor siphoned or poured off and the residue collected and dried.

Precipitation of the Silver by Sulphides

This is the oldest and the cheapest method of recovering silver. It is obtained as a silver-sulphide mud containing from 40–70 per cent of silver.

* Details of more elaborate apparatus, semi-automatic in action have been published by Kodak as well as many investigations into additions, etc., which facilitate the process, and will be found in the volumes of *Abridged Scientific Publications from the Kodak Research Laboratories* from the year 1933-4 onward.

Sodium sulphide is usually used, although the *potassium salt*, liver of sulphur can be used but is more expensive. The great disadvantage of the method is the evolution of *sulphuretted hydrogen gas* which occurs. On this account the operation must always be carried out in the open air and as far away from the dark-room as possible, as sulphuretted hydrogen is fatal to sensitive photographic materials. The amount of sulphuretted hydrogen produced can be greatly reduced by neutralising the fixing bath with soda before the sodium sulphide is added. The bath can be tested with *litmus paper* to make sure that it is alkaline. In general, about one ounce of a 20 per cent solution of sodium sulphide is required for each 10 ounces of bath.

When the precipitate has settled the overlying solution is tested with a few drops of *sodium sulphide* solution. If no brown cloudiness is produced precipitation is complete; if not, then more sodium sulphide must be added. The residue is treated in the same way as if it had been precipitated by metal powder.

Precipitation of Silver by Green Vitriol

This is a cheap method and is free from objectionable smell. Its disadvantage lies in the precipitation with the silver of an excess of *hydroxide of iron*.

For each part of silver in the bath there is required 5 parts of *green vitriol* (*ferrous sulphate*), and rather more than 5 parts of *caustic soda*.

The following details of the method are from *H. Arens and J. Eggert*: For each part of silver in the bath add 5 parts of green vitriol, which should be dissolved in water and sufficient caustic soda added to completely precipitate the whole of the iron as hydroxide; as soon as this has happened the liquor is added to the fixing bath, which must be already neutralised, well stirred and left to stand for 24 to 48 hours. It is essential that the bath after the addition of the iron hydroxide should be strongly alkaline.

Precipitation with Sodium Hydrosulphite

A somewhat expensive method, but one producing a clean and pure silver. Each part of silver in the bath requires 3 parts of *hydrosulphite*. ($\text{Na}_2\text{S}_2\text{O}_4$.) Precipitation is facilitated by warming the bath to about 120°F .

The required quantity of hydrosulphite is added, along with five times that quantity of *anhydrous sodium carbonate*.

The Baths from which Silver has been Recovered

Many attempts have been made to find methods of precipitating the silver in such a way that the fixing bath would be regenerated and so could be used again. The only method which allows of this is the *electrolytic*, for all the other methods result in the accumulation of much unwanted material in the bath and in most cases result in the decomposition of some or all of the hypo.

WASHING AND DRYING

Fixation of a negative is always followed by a thorough washing, for in addition to correct fixing the permanence and good keeping properties of the negative are entirely dependent on the efficiency and completeness of the final wash which must *remove every trace of fixing bath* and all other soluble salts from the film.

Technique of Washing

Washing must never be attempted in a perfunctory manner. Its purpose will not be fulfilled unless the water is frequently *replaced by a fresh supply*, or when the washing is carried out in a stream of *running water*.

To attempt washing in a dish, or the arrangement shown on page 118, is to risk failure because in such cases the water is not efficiently renewed. A distinct improvement is to lead the water by means of a rubber tube so that it *enters at the bottom of the dish*. In this way the incoming stream of water catches up and mixes with the heavier solution dissolved out of the film and so removes it. Many of the washers on the market are provided with a syphon which *empties them from the bottom* of the washer, and so provides a practical solution to the problem.

The *time required* for washing naturally depends in some measure on the *quantity of water* available and the *number of the negatives*. With a good supply of running water 30 minutes should suffice, but if there are many negatives being washed this time may be increased to 40 minutes.

If running water is not available, then the water in which the negatives are washing must be changed at *intervals of not more than 5 minutes*, and 5-6 such changes are essential.

As to the quantity of water to use, use as large a volume as possible but not less than about 8 ounces for each negative

$2\frac{1}{4} \times 2\frac{1}{4}$ inches or *pro rata*. (200 c.cm. per square decimetre of surface.)

Washing in Sea Water

The use of sea water for washing photographic materials is practical only when a final wash of about five minutes in fresh water is used. This final wash removes, as tests of the *Kodak Research Laboratories* have shown, the residual salts from the material and thus prevents rapid fading of the image caused by these salts in the presence of hypo, and absorption of moisture by the hygroscopic sea salts.

The removal of hypo is greatly accelerated during washing in sea water as compared with fresh water. As a result, it is recommended that films and prints be washed in sea water for about one-half of the usually recommended times, and finally for about five minutes in fresh water.

An increase of 20 to 40 degrees in the temperature of sea water increases the rate of washing by 25 to 50%, but washing at as low a temperature as 50°F. (10°C.) removes the hypo more rapidly than at 70° F. (21° C.) in fresh water. The total time involved in washing in sea water followed by fresh water is somewhat less than required in fresh water alone.

Control of Washing

The occasion may arise when it is necessary to test the efficiency of washing or to discover how long it takes. It must be remembered that washing must remove not only every trace of *hypo* but also any *soluble silver salts* in the film. Two tests serve to find out whether washing has been complete. The first is for the hypo.

139.—HYPO TEST SOLUTION

Distilled water	...	...	...	6 ounces	150 c.cm.
Potassium permanganate	...	...	...	6 grains	0.3 gram
Caustic soda	...	...	...	12 grains	0.6 gram
Distilled water to make	...	...	...	10 ounces	250 c.cm.

To make the test, pour about 8 ounces (200 c.cm.) of water into a glass, add about 20 minims (1 c.cm.) of the above solution, and allow some of the water to drain from the plate or film being washed into the test glass.

If there is *still hypo* present the *violet colour of the permanganate* will be discharged in a few seconds, and the test solution will take on a *yellow colour*.

To test for *silver* a *filter paper* can be impregnated with a

140.—SILVER TEST SOLUTION

2% solution of sodium sulphide

This should be done away from the dark-room. The paper can be dried and when used for the test one or two drops of water are allowed to drain from the plate or film on to the impregnated filter paper. If silver salts are present there is a *brown or yellowish-brown colour* where the drops have soaked into and spread in the filter paper.

Another test is to take a strip of *unexposed film* which has not been developed and *fix and wash it* simultaneously with other material. When washing is considered complete, this strip is immersed in the above silver test solution. Any trace of silver salts in the film will give rise to a *brown coloration*.

This test is also useful in that it can indicate that the fixing bath is exhausted, and that insoluble silver salts are remaining in the film. In this case the strip of *fixed and washed film is divided into two*. One part is tested when washing should be complete. If discoloration occurs the washing is continued *for another 15 minutes* and the second strip is tested. If this still shows the discoloration then the fixing bath is *not working* properly and must be replaced by a fresh one, and the whole of the material washing must be re-fixed and washed again.

Shortening Washing by Chemical Means

The fact that washing is normally a long operation has led many people to attempt to shorten it by chemical means. A number of substances have been used, all of which are oxidising substances which destroy or decompose hypo. The most important are : *Potassium persulphate, potassium percarbonate, potassium permanganate, sodium hypochlorite, chloramine T.*

It must be admitted that the value of such methods is very doubtful. Unless they are used in very dilute solution,

there is real *danger of their attacking the image*, for it will be noted that all belong to the class of compounds which we call reducers (see page 228). There is also the possibility that the products of the reaction will remain in the film and have a bad influence on its *keeping properties*. Hence even when they are used a short wash must follow.

A better method is to use:

141.—HYPO REMOVER

5–10% solution of sodium carbonate or bicarbonate

in which the negative is bathed for 5 minutes. A short wash will then remove every trace of hypo.

A new hypo-eliminator, recommended by J. L. Crabtree, C. T. Eaton and L. E. Muehler consists of two volatile chemicals, hydrogen peroxide and ammonia. This combination oxidises hypo to sulphite which is inert and excess eliminator, being volatile, evaporates. The new eliminator is intended for use with paper positives or negatives. It is difficult, if not impossible, to remove the last traces of hypo from paper and, as a result, the sulphur in the residual hypo sooner or later attacks any silver image forming a yellowish-brown silver sulphide, the common sulphiding or fading.

142.—HYPO ELIMINATOR FOR PAPER MATERIALS

Water	20 ounces	500 c.cm.
Hydrogen peroxide 3% solution ...	5 ounces	125 c.cm.
Ammonia 3% solution	4 ounces	100 c.cm.
Water to make	40 ounces	1,000 c.cm.

To make 3% ammonia dilute one part of .880 ammonia with 9 parts of water.

Paper prints or negatives should be given as thorough a wash as possible, about 30 minutes at 65°–70°F. (18–21°C.) in running water. At lower temperatures the washing time should be increased and for double weight prints or X-ray paper negatives the time should be doubled. Then immerse

each print in the hypo-eliminator for about 6 minutes at 70°F., 21°C.) and finally wash for 10 minutes. About 50 prints 10×8 or equivalent can be treated in one gallon of the solution.

With negatives or transparencies on glass or film hypo can usually be removed completely by water alone without the use of a hypo eliminator. If the washing process has to be speeded up then a supplementary alkaline bath can be used. The negatives, etc., can be washed in running water for ten minutes and then treated in the following bath.

143.—HYPO ELIMINATOR FOR NEGATIVES

Ammonia '880	...	...	...	4 ounces	100 c.cm.
Water to make	...	...	...	40 ounces	1,000 c.cm.

The negatives are bathed in this solution for 3 minutes and then washed for 2-3 minutes.

This formula is preferable to No. 141 as being volatile there is no solid residue left in the gelatine film of the negative.

Drying

When washed negatives should be dried in a dust-free place. Film can be hung free with a fairly heavy clip below to prevent air currents blowing it about too freely. Plates should be in a drying rack.

Before being put to dry, both sides of negatives, whether plates or films, should be gently but firmly wiped with a piece of viscose sponge or similar material, to remove all superfluous water (see page 122).

Not only does this accelerate the drying, but it removes any spots or flecks of gelatine which may have settled on the film, and it removes the possibility of small areas of irregular density due to drops of water on the film.

Drying can be accelerated by using warm air propelled by a fan. The temperature should not exceed 85-88°F. (30°C.), otherwise melting of the gelatine may occur. In

the larger drying cupboards used in the photographic business the heating unit is part of the whole installation (see page 122).

Where very *rapid drying* is necessary a spirit bath may be used.

144.—BATH FOR RAPID DRYING

Dilute the spirit with 10–20% water

Dilution of the spirit is necessary to prevent attack on the celluloid of the film. The bathing should last 3–4 *minutes* and the film can then be rapidly dried in a current of air. With *methyiated spirits* there usually occurs a more or less milky turbidity in the film, but this does not usually interfere with the printing from it.

Another method of quick drying depends on the use of a concentrated solution of a salt:

145.—ALTERNATIVE BATH FOR RAPID DRYING

Saturated solution of potassium carbonate

In this the film is immersed for a minute and then wiped dry with *chamois leather*.

146.—ALTERNATIVE BATH FOR RAPID DRYING

Saturated solution of magnesium sulphate (Epsom salts)

may be used for a like purpose; in this case the film is given half a minute in the salt solution, then *squeegeed* free from excess solution, given a *spirit bath* for a second or two and then dried in a few seconds in the stream of air from a fan.

These methods of very rapid drying are used in press work where often every second is of importance. Negatives dried by such means are usually used to produce enlargements. If they are to be preserved they should receive a *thorough washing as soon as they have provided the necessary enlargements*, otherwise the presence of salts in the film will lead to damage and disintegration.

THE AFTER TREATMENT OF THE NEGATIVE

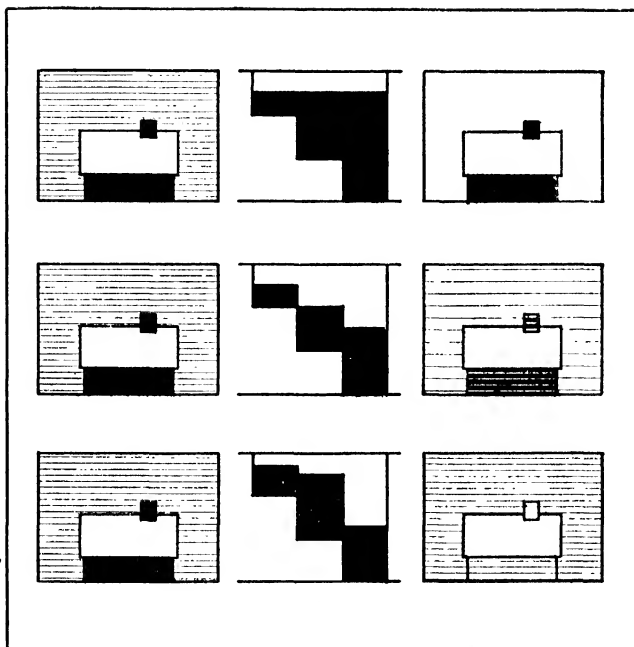
The correcting of negatives by after treatment, in particular by reducing or by intensification, has lost much of its former importance. The reasons for this are first the very wide range of gradations available in modern papers, which permit of good prints from negatives that are hard or soft, thick or thin, and second, the very notable latitude in exposure and in manipulation possessed by modern negative material, as a result of which the really poor negative is comparatively speaking a rarity.

Hence the correcting of a negative by chemical treatment is called for only in *exceptional cases*, or when the negative has to be suited to some special positive material which is only available in a restricted range of contrasts. A particular case which may arise is the preparation of *lantern slides* or *diapositives*, for here the material available does not appear in a wide range of contrasts. Another possibility is the desire to use a *special paper* which is only available in a limited variety of contrasts.

REDUCTION

The object of reduction is, as its name implies, the *reducing of the density* of a negative; it may be the correcting of *over-exposure* or *over-development*.

Errors in exposure or development may display themselves in various ways in the negative and variously affect its character. The choice of the right reducing agent to use in any particular case will go far to bring about the necessary correction. The way in which various reducers act is shown on page 229, where the gradation of various negatives is shown diagrammatically in the form of a stairway



REDUCTION

Reduction consists in reducing the density of the negative. Reducers can act in several ways, as the diagram shows. The *middle* series illustrates a section through a negative with the three divisions of shadow, middle tone and high lights. The diagrammatic representation of the house shows the effect of reduction. On the *left*, the negative before treatment, and on the *right*, after reduction. *From top to bottom*: First, subtractive reduction. Second, proportional reduction. Third, super-proportional reduction.

of densities. They give a section through the film of the negative showing the three steps of varying heights representing shadows, middle tones and high lights. The various reducers can act in three different ways which we will now describe.

(1) The reducer removes the same quantity of deposit from shadows, middle tones and high lights. It planes down the surface of the negative deposit evenly (page 229), and to this type of reducer we give the name *subtractive*. As the diagram shows the greatest effect is in the shadows, less in the middle tones and least of all in the high lights. Hence the general effect is to *increase the general contrast* of the negative. Reducers of this type are *Farmer's* (see page 231) and *Bellitzki* (see page 232). They are particularly adapted for reducing negatives where the shadows want clearing and where a general increase in contrast is desirable, as is particularly the case with *over-exposed negatives*.

(2) The reducer acts proportionally to the amount of silver present, that is it removes but *little from the thin parts, more from the middle tones and most in the heavy densities* (see page 229). From the diagram it will be seen that the action results in a notable reduction in the density of the whole negative, the total density of which may be reduced to about *one half*. It might be said to represent the opposite of over-exposure where, as we have seen (see page 30), increasing length of development gives increased density without notably increasing the contrast of the negative. Reducers of this type are called *proportional*, and the best known examples are *potassium permanganate* (see page 232), and mixtures of *permanganate and ammonium persulphate* (see page 232). These proportional reducers are used to correct *over-developed negatives*, or all those in which the densities are too heavy.

(3) The reducer attacks the *heavy parts of the negative more strongly than the middle tones and lighter parts* (see page 229). It is called *super-proportional* for it tends towards a reduction

of the general contrast and so is suitable for improving negatives which are too contrasty. That applies particularly to those which have had a *short exposure and been over-developed*. In such cases it is important that the details in the shadows are not attacked for, by reason of the under-exposure, they are already very thin and weak. Reducers of this type comprise : *Ammonium persulphate* (see page 233). *Benzoquinone* (see page 234). *Iron chloride citric acid* (see page 234). *Re-development* (see page 235). *Bleaching processes* (see page 237). *Toning processes* (see page 236).

Subtractive Reducers

The best known and most widely used subtractive reducer is Farmer's solution. It is almost always kept in the form of two stock solutions.

147.—FARMER'S REDUCER

A.	Hypo	...	...	...	...	1 ounce	25 grams
	Water up to	...	...	...	...	10 ounces	250 c.cm.
B.	Potassium ferricyanide	...	...	...	...	$\frac{1}{2}$ ounce	12.5 grams
	Water up to	...	...	...	...	5 ounces	125 c.cm.

Immediately before use take 4 ounces (100 c.cm.) water, 4 ounces (100 c.cm.) of solution A and 2 drams (6 c.cm.) solution B and mix well. The action of the reducer depends upon the proportion of solution B, the *more B is present the more rapid the action*, but the strength given above is convenient for good control of the process.

Caution : The stock solutions keep indefinitely, the mixed solution has very little keeping power.

The reducing should be watched carefully, it is best to treat the negative for about *20 seconds in the reducer*, then rinse well and examine, repeating the operation until the required reduction has been reached. Reduction can be undertaken immediately after the negative has been fixed, only a *short wash* being necessary before placing the negative in the reducing bath. When reduction is complete the negative is well washed and dried. Such reduced

negatives always show a *shiny surface* due to the silver having been removed from the outside layer of gelatine. (See page 229.)

Belitzki's reducer works in a similar manner to Farmer's.

148.—BELITZKI'S REDUCER

Ferric chloride cryst.	$\frac{1}{4}$ ounce	6.5 grams
Potassium or sodium oxalate	$\frac{1}{4}$ ounce	12.5 grams
Sodium sulphite	160 grains	8 grams
Water to make	8 ounces	200 c.cm.

Before use add 60 grains (3 grams) *oxalic acid crystals*, shake well until the solution turns green, allow to settle, pour off the supernatant liquor from the crystals and add 2 ounces (50 grams) *hypo*. For use take one part of this solution and dilute with 11 parts of water.

Proportional Reducers

The following formula is midway in properties between subtractive and a true proportional reducer.

149.—PERMANGANATE REDUCER

A. Potassium permanganate	40 grains	2 grams
Water to make	20 ounces	500 c.cm.
B. Water	20 ounces	500 c.cm.
Sulphuric acid conc.	20 minims	1 c.cm.

Immediately before use take 4 ounces (100 c.cm.) of water and add 2 drams (7 c.cm.) each of A and B.

To produce a correctly proportional reducer potassium permanganate is combined with ammonium persulphate as follows :

150.—PERMANGANATE-PERSULPHATE REDUCER

A. Potassium permanganate, 1% solution	$\frac{1}{4}$ ounce	12.5 c.cm.
Sulphuric acid, 10% solution	$\frac{1}{4}$ ounce	6.5 c.cm.
Water to make	20 ounces	500 c.cm.
B. Ammonium persulphate	$\frac{1}{4}$ ounce	12.5 grams
Water to make	20 ounces	500 c.cm.

For use take 1 part A, 1 part B and 4 parts of water.

If in either of the above cases the negative shows a *brown stain* after reduction, this can be removed :

151.—STAIN REMOVER

Sodium sulphite	...	...	...	6 ounces	150 grams
Oxalic acid	...	...	...	1 ounce	25 grams
Water to make	...	...	...	40 ounces	1,000 c.cm.

Super-proportional Reducers

The property of reducing the denser parts of the negative in preference to the middle tones and shadows is possessed in an unusual degree by the ammonium persulphate reducer. Ammonium persulphate is, however, notably subject to *deterioration* on keeping and is also *easily affected* by other substances, hence successful control of reduction when using it requires special precautions. The usual solution used consists of :

152.—AMMONIUM PERSULPHATE REDUCER

Ammonium persulphate	...	...	...	50 grains	2.5 grams
Sulphuric acid, 10% solution	...	...	...	20 minims	1 c.cm.
Water	...	...	...	4 ounces	100 c.cm.

If the tap water contains chloride or lime salts *distilled water* should be used. Also when fresh the crystals of persulphate *crackle* as they dissolve; if this does not occur the freshness of the persulphate is suspect and the action of the reducer will be reduced or may be absent.

Some workers prefer as an alternative solution the following :

153.—ALTERNATIVE AMMONIUM PERSULPHATE REDUCER

Distilled water	...	...	...	4 ounces	100 c.cm.
Ammonium persulphate	...	...	...	50 grains	2.5 grams
Ammonia 0.910	...	...	...	40 minims	2 c.cm.
Hypo	...	...	...	50 grains	2.5 grams

All negatives that are to be reduced with persulphate must be very *thoroughly washed*. The negative must be carefully watched during the process of reduction, preferably at

Intervals of not more than *15 seconds*. The rate of reduction varies with *different materials*, with some it is slow, with others very rapid. As soon as the desired degree of reduction is approached the process should be stopped. This can best be done by using the following stop-bath :

154.—STOP BATH FOR AMMONIUM PERSULPHATE REDUCER

Sodium sulphite	...	...	...	...	$\frac{1}{2}$ ounce	12.5 grams
Water to make	...	...	...	...	4 ounces	100 c.cm.

The negative is given a rinse and placed in this bath for a minute or so and then given a thorough final wash.

Most of the earlier failures with persulphate reducers can be traced to the use of old and partially decomposed, or to impure persulphate. They had the effect, however, of inducing workers to use other methods which were less unreliable. Of these one well used formula is that using benzoquinone.

155.—BENZOQUINONE REDUCER

Water	...	...	...	...	4 ounces	1,000 c.cm.
Sulphuric acid conc.	...	...	...	...	50 minims	3 c.cm.
Benzoquinone	...	...	...	...	20 grains	1 gram

The well washed negative is treated for *4–5 minutes* in this solution.

Ferric or iron chloride acts similarly to persulphate when used in conjunction with citric acid as follows :

156.—IRON CHLORIDE REDUCER

Water	...	...	...	...	20 ounces	500 c.cm.
Ferric chloride	...	...	...	...	160 grains	8 grams
Citric acid	...	...	...	...	1 ounce	25 grams

When a very decided reducing action is required the negative is passed from this bath into a

157.—FINISHING BATH FOR IRON CHLORIDE REDUCER

10% hypo solution

for *1 to 2 minutes*.

For the reduction of extremely dense and contrasty negatives the following special formula has been suggested by E. Leitz (London), Ltd., and Agfa, Ltd.

158.—IRON AMMONIA ALUM REDUCER

Three solutions are required

A. Potassium ferricyanide	... .. 200 grains	10 grams
Potassium dichromate 1% solution	25 minims	1.5 grams
Water to	... .. 40 ounces	1,000 c.cm.
B. Iron ammonium alum	... .. 400 grains	20 grams
Water to	... .. 40 ounces	1,000 c.cm.
C. Oxalic acid cryst.	... .. 2 ounces	50 grams
Water to	... .. 40 ounces	1,000 c.cm.

For use take equal volumes of A, B and C and mix well.

The well washed negative is immersed in the reducer for ten minutes at normal temperature. A longer treatment will do no harm but it is essential that treatment should be complete. Then rinse the negative in water and immerse in a 3% solution of plain hypo (not acid) for five minutes. Finally wash well and dry.

Caution: The separate solutions keep well but the reducer when once mixed does not keep. It deteriorates with great rapidity in bright light and therefore the process should be carried out in subdued or artificial light.

Re-development

A useful and controllable method of reducing the contrast of a hard negative is the so-called re-development method in which the negative is just *bleached* in a suitable bleaching bath and is then *re-developed* to the desired contrast and density. This is sometimes called *harmonising*.

What actually happens is that during the so-called bleaching process the developed silver image of the negative is *re-converted into chloride or bromide* and so can be developed again to the desired gradation and density. For this purpose it is preferable to use a somewhat *slow working fine-grain developer*; as soon as the required density and gradation are reached the re-developed negative is thoroughly fixed out.

A useful bleaching solution is :

159.—BLEACH BATH FOR RE-DEVELOPMENT

Water	...	...	...	...	40 ounces	1,000 c.cm.
Copper sulphate	...	...	...	...	4 ounces	100 grams
Sodium chloride (common salt)	...	...	...	...	4 ounces	100 grams
Sulphuric acid conc.	...	...	...	...	1 ounce	25 c.cm.

Bleaching must be thorough and *no trace* of the original reduced silver image must remain. When this is accomplished, wash for a few minutes until the image is pure white and re-develop with the following developer.

160.—FINE-GRAIN RE-DEVELOPER

Water	...	...	...	...	40 ounces	1,000 c.cm.
Paraphenylenediamine	...	...	...	...	60 grains	3 grams
Sodium sulphite	...	...	...	...	1 ounce	25 grams

Development must be carried out until the image is plainly seen through the *back of the negative*, otherwise the gradation will suffer and the negative be too thin. Another developer, somewhat more energetic, which can be used for this purpose is the metol single solution (No. 1), used well diluted. As a general guide the re-developed negative should appear not very different to the original negative before bleaching. If it is now *rinsed* and thoroughly *fixed* it will be found to have distinctly less density and a less steep gradation.

A somewhat similar effect, but one which does not correct graininess, is obtained by blue-toning the silver image, as follows :

161.—BLUE TONING BATH

A.	Water	...	...	...	...	40 ounces	1,000 c.cm.
	Potassium ferricyanide	...	...	...	...	$\frac{1}{2}$ ounce	10 grams
	Potassium dichromate, 1% solution	...	...	...	...	30 minims	2 c.cm.
B.	Water	...	...	...	...	40 ounces	1,000 c.cm.
	Iron alum	...	...	...	...	$\frac{3}{4}$ ounce	20 grams
C.	Water	...	...	...	...	40 ounces	1,000 c.cm.
	Oxalic acid	...	...	...	...	1 ounce	25 grams

For use take equal volumes of A, B and C and mix to form the toning bath.

The toning should be carried out in *subdued light* and will require *8-10 minutes*. Then *rinse* well and *fix* in a plain, (not acid) fixing bath. Wash well and *wipe off* all superfluous water before drying.

Another interesting method of varying and bettering the contrast makes use of the idea of *protecting the silver in the shadows* or thin densities of the negative either by depositing there a substance not attacked by the reducer or by converting the silver into a compound which equally is not attacked. To do this the negative is given a superficial bleach in the following bath:

162.—BLEACH BATH FOR SUPER-PROPORTIONAL REDUCING

Water	...	...	...	...	4 ounces	100 c.cm.
Mercuric chloride	...	...	...	...	40 grains	2 grams
Potassium bromide	...	...	...	...	40 grains	2 grams

The time of the bleaching is so arranged that only in the shadows and the thinner middle tones does bleaching take place. Hence when seen *through the back* of the negative all the parts that are to be reduced must remain *black*.

When this is achieved the negative is *washed* well and treated in a

163.—GOLD CHLORIDE BATH

Solution of gold chloride 1 : 500

This will have the effect of *darkening all the bleached parts* and as soon as this happens the bathing is stopped. The negative is now washed and treated with *Farmer's reducer* until the heavy densities are reduced to the required value.

With experience this is a very practical and useful method and can provide almost any desired alteration of contrast.

Variations of the method consist in the use of *gold or selenium toning* of the image, *omitting the bleaching bath*; in this way the toned parts are protected from the action of the reducer. The bleaching method is, however, safer and allows of better control as the observation of the image

during the bleaching is a certain guide to the progress of the operation. In the gold and selenium toning there is no alteration in image colour, hence there is no observable change to act as a guide to the completeness or otherwise of the reaction.

INTENSIFICATION

Negatives which are too soft and thin, either through *over-exposure, too short development or other mistake*, can be improved by intensification. This is called for when it is not possible to produce a satisfactory print by the choice of a suitable hard gradation paper.

Intensifying consists in *depositing either metal or a metallic compound* of black or dark colour on the silver forming the negative image and so increasing its printing density.

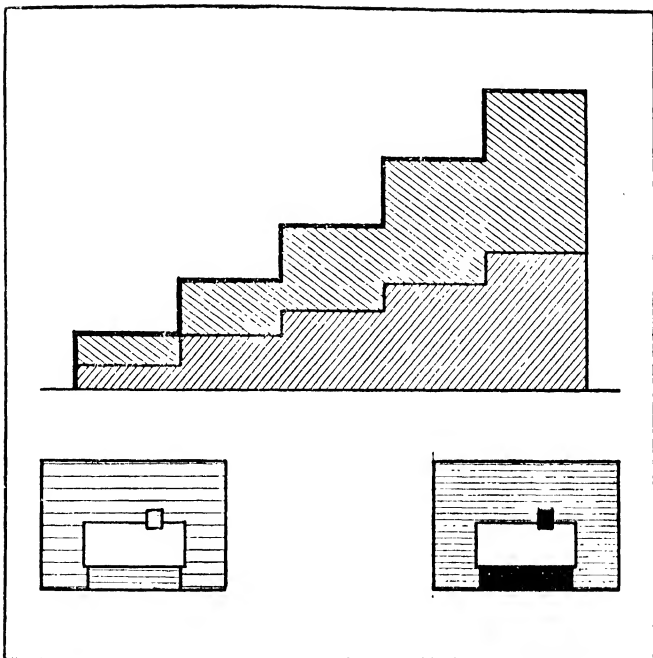
There is one reservation to be made here, and that is the fact that some enlarging papers to-day are *orthochromatic*.^{*} With such papers a negative having a *yellow-brown image* such as results from *uranium* intensification will not give the same result as on a normal, not colour sensitised bromide paper. Hence care should be used in the choice of the method of intensification.

In the following formulae the different types of intensifier are separated according to the degree of density and contrast they can confer on the negative. With the range of printing and enlarging papers available to-day it will generally be found convenient to use an intensifier of *medium type*, e.g., *mercury, chromium or dyestuff*.

It must be emphasised that one can only intensify when there is some image to work on. If under-exposure has been so gross that *no image* has been developed in the shadows and only clear glass exists, then there is nothing to intensify and no use in attempting it.

The action of intensifiers on the negative image is shown

^{*} See *Enlarging* by C. I. Jacobson, Focal Press, London, W. I.



INTENSIFICATION

Intensification of a weak negative consists in increasing its density by the addition of a black or dark-coloured layer through chemical action. In this way the contrast of the negative can be increased.

on page 239. It will be seen that with almost all intensifiers the denser parts of the image are *more strongly intensified* than the shadow details, hence the *contrast is increased*. These are just the properties required, for in the majority of cases our reason for intensifying a negative is to increase density and also to obtain greater contrast.

Mercury Intensifier

This is the most widely used method. The negative must be thoroughly *fixed and washed* before intensification is attempted. Any trace of *hypo* left in the negative will cause indelible stains to appear.

The negative is first bleached in the following solution :—

164.—BLEACH BATH FOR MERCURY INTENSIFICATION

Mercuric chloride	...	...	...	40 grains	2 grams
Ammonium chloride	...	...	...	40 grains	2 grams
Water	...	...	...	4 ounces	100 c.cm.

Bleaching must be carried on until all trace of the black silver image has been replaced by a *grey-white image*.

Blackening is carried out after the bleached negative has been given a short wash and may be done with :

165.—BLACKENING BATH FOR MERCURY INTENSIFICATION

- (1) A 10% solution of sodium sulphite or
- (2) A 5% solution of ammonia or
- (3) By using any normal developer

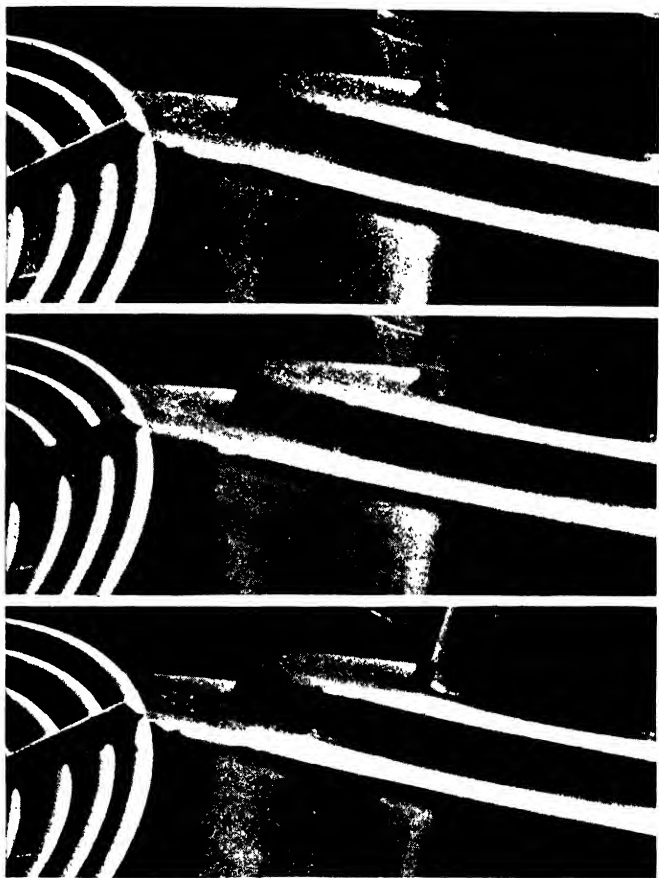
Of the three the *first* gives the least effect and the *third* the most. The *second* gives an image which does not withstand prolonged light action.

After blackening the negative should be well *washed*.

A single solution mercury intensifier can be made up as follows :

166.—SINGLE-SOLUTION MERCURY INTENSIFIER

Mercuric chloride	...	...	...	200 grains	10 grams
Ammonium sulphocyanide	...	...	...	120 grains	6 grams
Water	...	...	...	4 ounces	100 c.cm.



FINE-GRAIN DEVELOPMENT

The developer has a very important influence on the grain of the negative. The naked eye may fail to detect grain or graininess, but enlarging will reveal it. A section of a negative was here developed 1. (top) in ordinary developer (p. 127), 2. (centre) fine-grain developer of the retarding type (p. 140) and 3. (bottom) a super-fine grain developer (p. 150).



INTENSIFICATION

The negative was badly under-developed but still showed all the essential detail; the density was, however, so low that even an extra-hard paper failed to produce a satisfactory print (top). By intensification (see page 238), however, a reasonably normal result (bottom) was obtained.—H. Gorny.



PROPORTIONAL REDUCTION

The negative was dense and contrasty, so that even when a soft paper was used the result was too hard (*left*). By the use of proportional reduction (see page 232) the negative was notably improved and (*right*) a good print obtained on a soft paper.—*H. Gorny.*



SUBTRACTIVE REDUCTION

The negative as a whole was somewhat too dense and was rather strongly fogged in the shadows (*left*). By the use of Farmer's reducer (see page 231) the fog was removed and the whole negative brightened up (*right*).—H. Gorny.



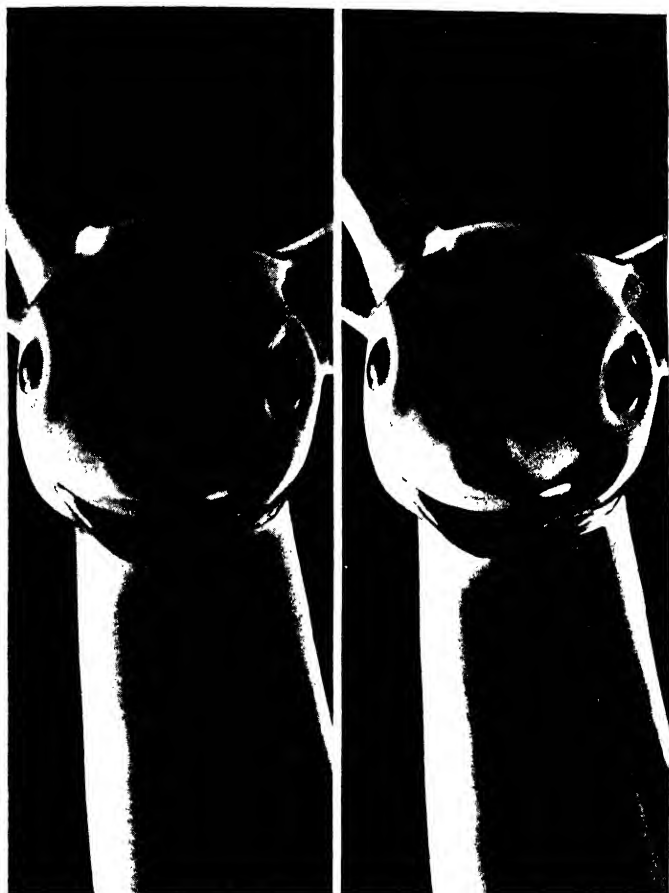
SUPER-PROPORTIONAL REDUCTION

The fault in the negative was mainly too dense highlights, whereas the rendering of the shadows was approximately correct (*left*). The treatment called for was the reduction of the high lights and so a super-proportional reducer, ammonium persulphate (see page 233), was chosen.—H. Gorny.



PARTIAL REDUCTION

The sky in the negative appeared almost opaque and would therefore print as a white expanse. As the negative was not suitable for treatment with the ammonium persulphate reducer, the process of partial reduction described on page 263 was used because in this case one had a single well-defined area which was comparatively simple to operate upon.—*Alexander.*



PARTIAL INTENSIFICATION

The high lights of the negative were well defined and the shadows had detail, but insufficient to provide a really good print or enlargement. An all-over intensification of the negative would have emphasised the high lights too much, so a partial intensification (see page 263) of the shadow areas was carried out.—*Alexander.*



BLOCKING OUT

This process, which is described on page 264, can be used particularly for emphasising the more important parts of a subject. It may be employed to hold back or to suppress entirely some unwanted portion of the background by blacking it out as seen in the picture on the *right*.
—Alexander.



RIGHT AND WRONG METHODS IN RETOUCHING

Left top. The right attitude and arrangement when retouching. The retouching desk is so arranged that it is evenly illuminated by light reflected from the mirror behind it, while the eyes of the operator are protected by the shade projecting from the frame of the desk.



TWO IMPORTANT OPERATIONS IN RETOUCHING

Left. Applying Mattolein (see page 269) with the aid of a linen swab before proceeding to retouch with a pencil. The matting is essential if the pencil is to take on the negative surface.

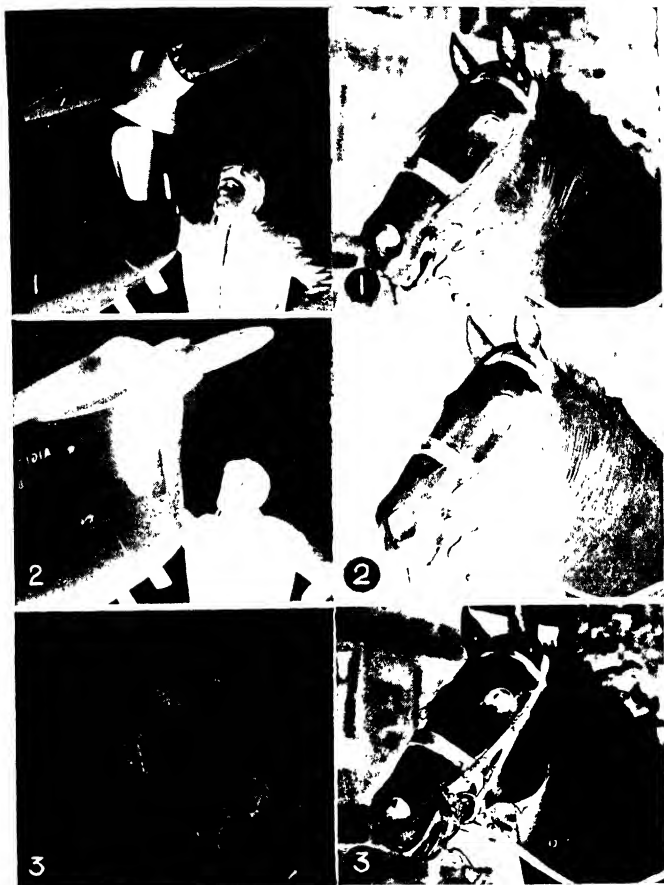
Right. Rubbing down the graphite powder which is to be used in local intensification or retouching. The negative must be treated with a matt varnish before the graphite is applied.—W. Nurnberg.

Continued from page 249.

The illustration *top right* shows none of these conditions fulfilled; the angle of the desk is wrong, the position cramped and the eyes subjected to a glaring light.

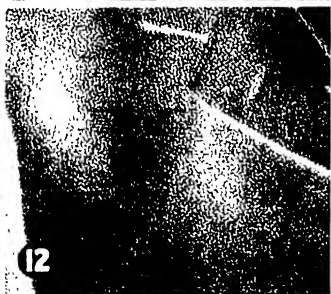
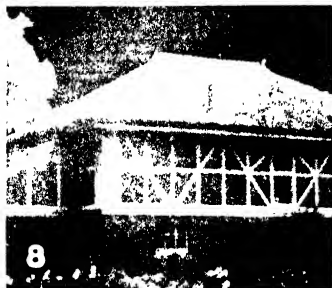
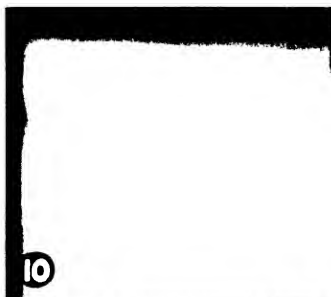
Left bottom. The correct method of holding the retouching pencil. It is held lightly and not too near the point, hence the danger of too heavy a stroke is obviated.

Right bottom. The wrong way to hold the pencil; it is held too tightly and too near the point. Control is difficult and the strokes will be too heavy.—W. Nurnberg.



DEFECTS IN NEGATIVES

Left. 1. Correct exposure. 2. Under-exposure (p. 278—1). 3. Over-exposure (p. 278—5). Right. 1. Correct development. 2. Under-development (p. 278—2). 3. Over-development (p. 278—4).



7. Grey fog all over (p. 279—6). 8. Reversal of the negative (p. 285—38). 9. Fogging through backing (p. 279—6b). 10. Black fog on edge of plate (p. 279—7). 11. Reticulation (p. 284—30). 12. Reticulation magnified.



13. Melting due to hot water. 14. Melting (p. 285—39). 15. Frilling (p. 285—36). 16. Finger marking (p. 102). 17. Marks caused by dust brush. 18. Contact during development (p. 110).



19



22



20



23



21



24

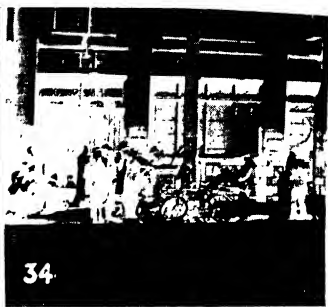
19. Irregular density (p. 284—27). 20. Streaks on the negative (p. 282—15). 21. Areas of higher density (p. 283—21). 22. Areas of lower density due to adding potassium bromide (p. 283—21). 23. Irregular development (p. 283—18). 24. Stop bath too strong.



25. Air bell marks (p. 284—28). 26. Air bells magnified. 27. Small blisters (p. 285—35). 28. Streaks (p. 282—15). 29. Small flecks (p. 284—26). 30. Dark flecks (p. 284—32).



31



34



32



35



33



36

31. Dust (p. 284—31). 32. Chemical dust (p. 284—31). 33. Drying marks (p. 284—34). 34. Water splashes (p. 284—34). 35. Water splashes (p. 284—34). 36. Holes in the film (p. 284—33).

Dilute one part with 9 parts of water for use. *Maximum* intensification requires about *10 minutes*. If longer treatment is given the image begins to lose density.

Mercuric Iodide Intensifier

The following is a simplified method of mercury intensification.

167.—MERCURIC IODIDE INTENSIFIER

To a solution of 120 grains (6 grams) mercuric chloride in 20 ounces (500 c.cm.) of water add a 10 per cent solution of potassium iodide until the voluminous red precipitate which forms is just re-dissolved. This will require about 3 ounces (75 c.cm.) of the iodide solution. To the mixture add the following solution:

Sodium sulphite, anhyd.	4 ounces	100 grams
Water to make	20 ounces	500 c.cm.

If the above intensifier be used alone, the intensified negative has *poor keeping* properties, it is therefore usual to blacken the intensified image by using any *normal developer*.

Uranium Intensifier

This method gives strong intensification but the image colour is yellow brown and the keeping properties of the intensified image are not good.

168.—URANIUM INTENSIFIER

A. Water	4 ounces	100 c.cm.
Uranium nitrate	20 grains	1 gram
Acetic acid glacial	$\frac{1}{2}$ ounce	12.5 c.cm.
B. Water	4 ounces	100 c.cm.
Potassium ferricyanide	20 grains	1 gram

For use take one part of A and two parts of B, mix, and then intensify to the required degree. Care must be exercised in *washing* the intensified negative, using running water and wash until the water runs smoothly over the intensified surface. If washing be prolonged the density

tends to regress. If the yellowish colour of the high lights is objectionable, it can be reduced by treating with

169.—CLEARING BATH FOR URANIUM INTENSIFICATION
5% solution of sodium chloride (common salt)

Chromium Intensification

This is a simple, easily controlled, and very satisfactory method which has largely supplanted mercury intensification. A stock solution of potassium dichromate, 10 per cent in strength is used to make up the following baths:

170.—CHROMIUM INTENSIFIER

Stock potassium dichromate solution						
(10%)	...	...	...	...	½ ounce	12.5 c.cm.
Hydrochloric acid conc.	...	...	...	...	5 minims	0.3 c.cm.
Water up to	...	...	...	...	4 ounces	100 c.cm.

171.—ALTERNATIVE CHROMIUM INTENSIFIER

Stock potassium dichromate solution						
(10%)	...	...	...	...	½ ounce	12.5 c.cm.
Hydrochloric acid conc.	...	...	...	...	25 minims	1.2 c.cm.
Water up to	...	...	...	...	4 ounces	100 c.cm.

No. 170 gives more intensification than No. 171.

The well washed negative is immersed in the bath until completely *bleached*; this converts the silver image into a combination of *chloride and chromium* compound. The negative is now *washed* until completely free from *yellow stain*, and *developed* by daylight, or after exposure to daylight with a normal developer.

A notable advantage of the method is that if sufficient intensification is not attained in the first attempt the whole treatment can be repeated.

Intensification by Re-halogenisation and Development

In cases where special chemicals are not available the bleaching bath used in *indirect sulphur toning* can be used as follows :

172.—BLEACH BATH FOR INTENSIFICATION

Water	...	...	...	...	40 ounces	1,000 c.cm.
Potassium ferricyanide	...	...	...	...	1 ounce	25 grams
Potassium bromide	...	...	...	...	$\frac{1}{2}$ ounce	12.5 grams

When fully bleached and well washed a strong intensification is obtained by pyro developer, namely :

173.—RE-DEVELOPER FOR INTENSIFICATION

Water	...	...	...	...	40 ounces	1,000 c.cm.
Sodium sulphite, anhyd.	...	...	...	...	$\frac{1}{2}$ ounce	12.5 grams
Pyrogallol	...	...	...	...	$\frac{1}{4}$ ounce	6 grams
Sodium carbonate, anhyd.	...	...	...	...	$\frac{1}{2}$ ounce	12.5 grams

This process may also be repeated.

Stain Intensification with Dyes

Most methods of intensification involve the danger that the *grain* of the negative may be *increased*, and such a result is quite incompatible with modern miniature camera materials. Such a danger is practically non-existent in the stain intensification process in which the negative image is first *bleached* and then converted into a *dye image* which is practically permanent. The process is carried out as follows:

174.—MORDANT BLEACH BATH FOR DYE INTENSIFICATION

Water	...	...	...	...	40 ounces	1,000 c.cm.
Copper sulphate	...	...	...	...	1 ounce	25 grams
Potassium citrate	...	...	...	...	2 ounces	50 grams
Acetic acid	...	...	...	...	1 ounce	25 c.cm.
Ammonium sulphocyanide	...	...	...	...	1 ounce	25 grams

The negative is completely bleached in this bath, is given a short wash and then treated with the following dyestuff solution. All the dyestuffs are in 1 per cent watery solution.

175.—DYE SOLUTION

Methylene blue	...	...	...	...	5 ounces	125 c.cm.
Rhodamine S.	...	...	...	...	$6\frac{1}{2}$ ounces	165 c.cm.
Neophosphine	...	...	...	...	$5\frac{1}{2}$ ounces	140 c.cm.

When the bleached negative is placed in the dye-bath care must be taken to ensure that the dye solution flows

rapidly and evenly over the whole surface; this may be helped by using a flat, soft *brush*. The dye-bath usually requires from 5–15 minutes, according to the amount of bleached image there is to be converted.

When complete, the negative is *washed* until the high lights are clear. Too long washing will tend to *retrogression* of the intensification. This possibility can be borne in mind when intensification has been a trifle too heavy.

The following alternative method for intensification with dyes has been recommended by E. G. Ashton and gives very good results :

The image is first mordanted with the aid of the following solution :

176.—KODAK T17 MORDANT BLEACH BATH

Uranyl nitrate	...	...	...	70 grains	8 grams
Oxalic acid	...	...	...	35 grains	4 grams
Potassium ferricyanide	...	...	...	35 grains	4 grams
Water to make	...	...	...	20 ounces	1,000 c.cm.

The chemicals are dissolved, separately each in about 5 oz. (250 c.cm.) of water, then to the uranyl nitrate solution is added first the oxalic acid, then the ferricyanide, and water is last added to make up the total bulk. This is a stock solution; store in the dark, and for use take 1 part and add 4 parts of water.

Immerse the negative in the working solution until a very slight chocolate coloured tone is produced—with a new bath $1\frac{1}{2}$ to 2 minutes will be needed. Then wash for 15 minutes (not longer) which should discharge all yellow stain.

177.—DYE SOLUTION

Malachite green	...	...	...	2 grains	0.2 gram
Auramine	...	...	...	1 grain	0.1 gram
Acetic acid (glacial)	...	...	...	4 mins.	0.5 c.cm.
Water to make	...	...	...	20 ounces	1,000 c.cm.

The dyes are dissolved in hot water and filtered ; when cool the acetic acid is added. Fresh acetic acid should be added each time the bath is used. If the dye is found to stain the clear parts of the image, the proportion of acid can be increased.

The time of immersion in the dye bath depends on the contrast required, and may vary from 2 to 10 minutes, after which no more dye will be taken up by the mordanted image. The final wash should be thorough so as to remove all traces of unmordanted dye. When this has been done, a trial print will show whether the intensification is sufficient. If not, the negative can be returned to the dye bath for further intensification so long as the original time was less than 10 minutes. If it has already had the full 10 minutes, the whole process must be repeated, starting from the mordanting bath. If too much dye is taken up, some of it can be discharged by immersion in 0.2 per cent ammonia solution.

Apart from its use as an intensifier, this procedure can be used for the reduction of grain-size in high speed emulsions. For this development is purposely arrested at an early stage, so giving a negative of fine grain but too flat to print. The negative is then intensified without the increase in grain-size that would have resulted if development had been continued to give the normal contrast.

Copper-Silver Intensifier

For very weak negatives *M. G. Zelger* recommends the following formula:

178.—COPPER-SILVER INTENSIFIER

A.	Water	...	...	...	20 ounces	500 c.cm.
	Copper sulphate	...	...	...	100 grains	5 grams
	Acetic acid glacial	...	...	...	1 ounce	25 c.cm.
B.	Water	...	...	...	10 ounces	250 c.cm.
	Potassium iodide	...	...	...	100 grains	5 grams
	Ammonia .880	...	...	...	2 ounces	50 c.cm.

Two parts of A and one part of B are mixed to form the bleach bath; the negative after bleaching is washed for 15 minutes and blackened in

179.—BLACKENING BATH FOR COPPER-SILVER INTENSIFIER

Water	...	...	...	...	10 ounces	250 c.cm.
Silver nitrate	...	...	...	...	20 grains	1 gram
Sodium acetate	...	...	...	...	80 grains	4 grams

If desired the film may be hardened after the bleach bath in saturated solution of potash alum.

RETOUCHING

The retouching of negatives to-day is usually confined to dealing with actual imperfections in the negative or to modifying some excess or want which detracts from the quality of the picture. In earlier days retouching reached such proportions that it was not uncommon to find the finished picture bearing but little resemblance to the original. Such "beautifying" is not the true object of retouching.

Plan of Work

If retouching is undertaken it should always be carried out in a definite order and according to a deliberate plan.

(1) The first stage is the wet retouch, sometimes called *chemical retouching*. This comprises the local or partial reduction or intensification of any areas requiring such treatment.

(2) The treatment of the dried negative comprises dealing with those portions which are too thin and which require *blocking out* or treating in such a manner as to reduce the amount of light which they can pass.

(3) If any slip be made in carrying out No. 2, then the matter can usually be remedied by treatment or *washing* of the negative.

(4) The next process will be the *mechanical reduction* of any part of the negative which is too dense, i.e., rubbing down.

(5) Then will follow, if required, any *knife-work*, which is used to reduce small local densities, to remove black spots and the like.

(6) The last retouching to be undertaken is that carried out with the *pencil*, and then it is usual to *varnish* the negative.

This long list does not mean that all or even any of these stages are necessary for every negative. It does mean that if more than one of the operations is required they should follow one another in an ordered sequence so that they do not interfere with one another.

Partial Reduction or Intensification

In normal reduction and intensification the whole of the negative image is treated, whereas in chemical retouching only *certain parts of the image* are singled out, as for example in a landscape it may be found that the sky is too dense and hence would print too light.

To partially reduce this portion of the negative the procedure is as follows.

Soak the negative for about *10 minutes* to swell the gelatine, place the negative on a *white tile*, or in a white dish. Take a paint brush, not too full, of *Farmer's reducer* (see page 231), and distribute the Farmer's reducer carefully over the sky to be reduced. The *line* where the sky meets the rest of the picture must be carefully traced and not overstepped. Care must be taken not to flood the reducer over the negative. After a few moments the negative should be well *rinsed* and examined to ensure that action is equal over the desired area. This should be repeated until the necessary amount of reduction has been achieved.

Where *very small areas* in the negative call for reduction the same procedure can be followed, but a *fine camel hair brush* should be used to apply the reducing solution. A useful tip is to *thicken the reducer with glycerine* so that it does not flow so easily and can be more easily confined to the necessary limits.

In special cases those parts of the negative which are not to be reduced may be *protected* by painting with a *waterproof varnish* such as *shellac*, this, of course, on the dry negative. When the varnish is dry the negative can be treated after

swelling in a reducer bath, washed and dried and the protective varnish then removed with *benzol* or *alcohol*.

Partial intensification can be carried out by similar means, using the various intensifiers that are normally used in baths (see page 238).

Shading and Blocking Out

This is used for those parts of a negative where the image is so *thin* that it will print too dark, and where local intensification is not possible, or unlikely to give the desired result.

Solutions of red or yellow dyestuffs are used which tint the gelatine of the negative and so retard the passage of light. Such substances are *Neo-Coccin*, *Vanguard yellow*, etc.

The art consists in tinting the required part of the negative perfectly evenly. To this end a *very pale solution* is used to begin with, the brush is well filled and applied firmly and evenly to the negative so that the whole area to be treated is flooded evenly with the dye solution.

With *films* the dye may be applied to the back of the film, when as in many cases, this carries a gelatine coat. It is not possible to use this method with unbacked 35 mm. (*miniature*) *film* for miniature cameras. With *glass plates* the dye is sometimes applied to the back but causes trouble when enlargements have to be made. When it is desired to use the back of the plate it must first be given a coat of varnish which can be prepared as follows:

180.—MATT VARNISH

Ether	...	...	...	...	7 ounces	180 c.cm.
Gum sandarac	...	...	...	...	$\frac{1}{2}$ ounce	18 grams
Gum mastic	...	...	...	...	80 grains	4 grams
Benzol	...	...	...	...	3 ounces	70 c.cm.

If the ether is quite water free, about 20 minims (1.5 c.cm.) of water should be added so as to ensure that the varnish will dry with a matt surface.

For dealing with quite small areas which require darkening *fine graphite powder* can be used, rubbing it into the matt varnish coating with a *leather stumping pencil*.

Where there are parts that require a little *lightening* in cases where the plate has been given a matt-varnished back, the varnish can be removed by a *knife* or by an *alcohol damped stump*.

In some cases it is necessary to cut out portions of a *negative* so that they do not print at all. This is usually the case with unwanted backgrounds, and the usual method is to use *photopake*, which is painted either on the face, or more usually on the back of the negative and so cuts out that part of the negative it covers.

Another method is to use the *matt varnish and tint* it strongly with a red, yellow or other dye so that no actinic light can pass. Such dyes as *congo red*, *quinoline yellow*, *malachite green*, etc., are used for this purpose, but the process is only suitable for use with glass negatives from which contact copies are required.

Spotting

Spotting is the name given to the operation of *removing or filling in small spots, flecks or pin holes* in the negative. The procedure naturally depends on the nature of the spot.

Whatever the type of spot the aim is to treat it so that it is hidden, hence if it be a pin hole in a light part of the negative, it is spotted out by using special *water-colour paint* and a very fine pointed *brush*. The first step is to ensure that the tint used is the same shade as that part of the negative where the spot occurs. This is achieved by a trial or two on a piece of white paper. Then the spot or pin hole is carefully touched with the point of the brush, laden with the retouching medium, until the required density is built up. *Photopake* is sometimes used, but the water colour retouching medium is preferable as photopaque on a thinly

covered part of the negative tends to give a light coloured spot or area on prints.

Some workers prefer to do their retouching on the print and not on the negative, but it is obvious that if many prints are to be made the retouching should take place on the negative before printing.

Dry Reduction

Reducing normally depends upon chemical action, that is the solution of part of the silver image, but local reduction can be carried out by mechanical means, that is by *rubbing down* or abrading the heavier parts of the image. *Globe metal polish* has long been used for this purpose, but if unobtainable a substitute may be prepared as follows:

181.—DRY REDUCER

Paraffin wax	...	...	...	...	1 ounce	25 grams
Tallow	...	...	...	...	1½ ounces	36 grams
Vaseline	...	...	...	...	4 ounces	100 grams
Oleic acid	...	...	...	...	2½ ounces	65 grams
Nitrobenzene	...	...	...	...	15 minims	1 c.cm.

This mixture is melted at as low a temperature as possible and stirred until thoroughly mixed. Then there is added with careful stirring and mixing while warm,

Tripoli (Finest Kieselguhr)	10 ounces	250 grams
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The *tripoli* may be replaced by very finely powdered *pumice* which has been sifted through fine silk bolting cloth. Or the pumice powder may be used dry or with the following medium :

182.—ALTERNATIVE DRY REDUCER MEDIUM

Oil of turpentine	...	...	...	2 ounces	50 grams
Benzine or carbon tetrachloride	...	...	...	2 ounces	50 grams

The application of the abrasive may be made with the aid of *artist's stumps*, either of *leather* or *paper*, or by using a *pen holder*, the rounded end of which has been covered with

linen or wash leather, or for very small areas *chisel* shaped pear or other similar wood tools.

When the reduction is complete every trace of the abrasive material must be carefully removed with *brush* and *alcohol* or *benzol*.

Knifing

This is normally a more drastic method of retouching than the use of abrasive, for it allows of the complete removal of part of the image if desired. The retouching knife must have a *razor edge* and the edge must be constantly renewed by the proper use of an *oilstone*.

Knifing is carried out by making *parallel strokes* one after the other until the whole area to be reduced has been covered. The process is now repeated with the direction of the strokes at a decided *angle* to the first set and so on. In this way if the work is carefully done the individual strokes are quite imperceptible.

With negatives which have already been reduced with *Farmer's reducer* the knife sometimes takes badly; In such a case the area can be lightly rubbed down with *Globe polish* or its substitutes.

Pencil Retouching

The art of pencil retouching can easily be abused, and its excessive use has brought discredit on certain branches of photography in past times. Used with discretion, that is not for the beautification of a picture but for the correction of blemishes or errors, it can perform valuable service.

In order that the negative will take the pencil properly, it is usually necessary to treat the negative with a *varnish*. Certain portrait plates and films are actually supplied with a *matt surface* to facilitate retouching, but in the absence of this a matt varnish must be used.

Varnishing

One of the most useful is the water varnish made up as follows :

183.—WATER VARNISH

Orange shellac	...	...	...	1½ ounces	36 grams
Borax	...	...	...	200 grains	10 grams
Carbonate of soda	...	...	...	40 grains	2 grams
Glycerine	...	...	...	30 minims	2 c.cm.
Water	...	...	...	16 ounces	400 c.cm.

The borax and soda are dissolved first in about half the water, the solution warmed and the shellac added and stirred until dissolved, which will probably require gentle heating. Then *filter* through clean linen and make up to the full quantity after adding the glycerine.

The negative can be bathed in this varnish and so given a matt coat, both back and front, which will easily take retouching.

Some workers prefer a warm alcohol varnish and a useful one is :

184.—ALCOHOL VARNISH

Bleached shellac (powdered)	...	...	8 ounces	200 grams
Gum sandarac	...	...	2 ounces	50 grams
Gum mastic	...	...	½ ounce	6 grams
Gum dammar	...	...	½ ounce	6 grams
Castor oil	...	...	5 drops	5 drops
95% alcohol	...	...	80 ounces	2,000 c.cm.

When the shellac and the gums are completely dissolved the varnish must be *filtered*. Before it is used the *plate* must be *warmed* and sufficient of the varnish poured on to flow evenly over the surface to be matted, the excess being allowed to flow back into the varnish bottle from a corner of the plate.

This matt coating can be *removed*, if necessary, by dissolving off with *alcohol*.

A cold varnish can also be used, namely :

185.—COLD VARNISH

Gum dammar	...	...	...	...	$\frac{1}{2}$ ounce	6 grams
Carbon tetrachloride	...	...	...	...	4 ounces	100 c.cm.
When dissolved add manilla copal	...	...	...	...	$\frac{1}{2}$ ounce	6 grams

Solution takes some time and is best helped by heating the mixture in a water bath. The varnish should be *filtered* hot. Note that it is not inflammable.

Another cold varnish is prepared by taking :

186.—ALTERNATIVE COLD VARNISH

Gum sandarac	...	...	...	...	2 ounces	50 grams
Benzene	...	...	...	...	8 ounces	200 c.cm.
Acetone	...	...	...	...	10 ounces	250 c.cm.
Alcohol 95 $\frac{0}{100}$	...	...	...	...	4 ounces	100 c.cm.

Solution can be aided by careful warming in a water bath and the varnish is best filtered warm. The cold varnishes can be applied to well dried negatives without their being warmed.

The *cold varnishes* give a somewhat *thinner film* than the warm varnish, but permit of an even *heavier retouching* being carried out.

Another type of matting is that which is applied with a *wad of linen* and not poured over the negative. These varnishes have the advantage that they dry very rapidly but are *not* particularly suitable for use on negatives which are to be *enlarged*.

187.—NORMAL MATTING VARNISH

Gum dammar	...	...	...	...	1 ounce	25 grams
Oil of turpentine	...	...	...	...	5 ounces	125 c.cm.

188.—RAPID MATTING VARNISH

Gum dammar	...	...	...	...	$\frac{1}{2}$ ounce	12 grams
Oil of turpentine	...	...	...	...	3 ounces	75 grams
Petrol-ether	...	...	...	...	3 ounces	75 grams
Oil of lavender	...	...	...	...	30 minims	2 grams

These two varnishes give a very thin matt coating which will only take *very light retouching*.

When negatives are intended for *enlarging* the varnish must be applied *equally* over the whole of the negative

surface, but for *contact prints* only the varnish can be applied just where *retouching* is required.

In addition to providing a surface which takes retouching in a satisfactory manner, these varnishes also act as a *protective coating* to the negative and preserve it from scratches or other change.

A simple protective varnish can be prepared from waste film which has been cleansed free from all gelatine coating and carefully dried.

189.—CELLULOID VARNISH

Celluloid	...	...	...	...	...	½ ounce	6 grams
Amyl acetate	...	...	...	...	...	4 ounces	100 c.cm.
Acetone	...	...	...	...	...	4 ounces	100 c.cm.

Applying the Varnish

For good results to be obtained it is important that varnish be applied so that an even coat covers the *whole of the negative*. The negative is first *dusted* carefully with a *soft brush*, and a small pool of the varnish *poured on to the centre of the plate*. By *tilting the plate* carefully, first one way and then another, the varnish is caused to *flow evenly* over the whole surface, finally, the plate is tilted so that the excess varnish *flows back into the varnish bottle* from the right lower corner.

To varnish *film negatives* they are first *fastened down to a glass plate* with a suitable cement such as "stay flat" and the process then carried out as for a glass plate. Note that *shellac or gum dammar* varnishes may be used with *films*, but the *celluloid* varnish must *not* be used as it would attack the film base.

Pencils for Retouching

Pencils of varying hardness are used in retouching. Soft pencils give dark marking and density, while harder

pencils give *lighter* effects. As a general rule a pencil should be chosen for a particular piece of work which will require to go over the area 4-5 times in order to build up the *necessary density*. The pencil is used to give a stippling effect on the film, and both practice and good judgment are required for success.

If, by chance, too heavy a retouch has been given, correction can be achieved by *removing the blackening with benzine or turpentine* and the area dealt with again.

All retouching work should be carried out on some form of *retouching desk*. This consists essentially of a frame (page 249), which encloses a *ground glass* sheet upon which the negative is laid. The frame can be set at any convenient angle and *light* from a window or other light source is reflected by a *mirror* through the ground glass screen. If artificial light is used, the mirror should be covered by a white carton or sheet of paper to *diffuse* the light.

PRESERVATION OF THE NEGATIVE

Preservation of Plate and Flat-Film Negatives

This is best obtained by using transparent *envelopes of parchment or cellophane*, upon which a consecutive number is marked or sufficient detail to identify the negative by. The envelopes with their negatives can be kept in plate or film boxes which bear on their cover details of the contents, or the boxes may be stacked in book-form on shelves and have labels on their ends. The orderly and precise worker will have a *catalogue* of his negatives which will contain their consecutive number and description.

A somewhat more costly method is to keep the negatives in *racked wooden boxes*, but this usually involves more room, as well as expense, than the average photographer desires to afford.

Preservation of Roll-Film Negatives

The question as to whether roll and miniature films should be kept in roll form or cut into one or more negatives hardly arises, for in *roll form films are almost certain to suffer damage* in one form or another, in addition to the danger of collecting dust and grit. They should therefore always be preserved *flat and cut*, either into *single negatives*, or in the case of miniature films, *two or three negatives at most*.

Here again *parchment or cellophane envelopes* should be used, marked with the negative number or detail and then preserved in larger envelopes or in boxes. With the 35 mm. (miniature) film it may be convenient to have as many as *6 negatives on one length*, and special envelopes for preserving such lengths are now available.

All negatives should be kept in suitable conditions. That is in a *dry, reasonably warm* place not subject to any wide

variations of temperature and well clear of any fumes from fireplaces, gas fires or the like.

Cleaning Film

Dirty and dusty or greasy film can be cleaned:

190.—FILM CLEANER

Acetic acid	...	...	...	...	...	1 part
Vaseline	...	...	...	...	...	5 parts
Carbon tetrachloride	...	...	...	...	...	100 parts

The solution is applied either with chamois leather or viscose sponge. Shake the solution well before using it. The film is lightly rubbed with the solution, being careful not to exert any serious pressure. After about 10 minutes the film is then dried with a soft clean chamois leather until every perceptible trace of the cleaner is removed, and the film appears quite dry.

Dealing with Scratches and Abrasions on Film

The trouble can be overcome comparatively simply so that the scratches are rendered imperceptible. The method consists in coating the film with a thin solution of gelatine which fills in the scratches and renders them incapable of affecting the optical properties of the film during printing.

191.—ANTI-SCRATCH SOLUTION

Water	...	...	...	...	20 ounces	500 c.cm.
Chloral hydrate	...	...	...	...	2 ounces	50 grams
Gelatin	...	...	...	...	$\frac{1}{2}$ ounce	12.5 grams

The chloral hydrate is dissolved first, then the gelatin, in small pieces, is allowed to swell in the cold and when swollen the whole is warmed on a water bath and stirred until solution is complete.

The temperature should not exceed 140°F. (60°C.).

The solution, which has reasonably good keeping properties, should be used at about room temperature.

DARK-ROOM HINTS

Antidotes for Poisons

Against Acids: Alkaline drinks, i.e., sodium bicarbonate, magnesium carbonate or a suspension of magnesium oxide. If these are not available, then quantities of warm water to induce vomiting. Milk and oil may also be used.

Acid splashes in the eyes. Wash with warm water or with very dilute sodium bicarbonate.

Against Caustic Alkalies: Drink strongly diluted vinegar or citric acid or apple juice. Suck pieces of ice. Milk or oil may be drunk.

Alkali splashes in the eyes. Wash with water or very dilute boric acid.

Gas Poisoning: Fresh air, remove constricting clothing artificial respiration.

Mercury Poisoning: Milk and white of egg.

Prevention and Ointment Against Dermatitis

As a preventive against dermatitis caused by metol to especially sensitive persons, the fingers may be rinsed both before and during development in :

192.—PREVENTIVE AGAINST METOL DERMATITIS

Hydrochloric acid	...	...	...	...	...	...	20 drops
Water	...	...	...	...	...	...	20 ounces

Where the skin is already affected, the following ointment should be used two or three times a day and before going to bed at night:

193.—ICHTHYOL OINTMENT

Ichthyol	...	...	...	...	...	...	10 parts
Lanoline	...	...	...	...	...	...	40 "
Boric acid	...	...	...	...	...	...	40 "
Vaseline	...	...	...	...	...	...	30 "

Removing Developer Stain from the Hands

Rub the hands well with a

194.—STAIN REMOVER

1% solution of potassium permanganate until they have taken on an overall *brown colour*, then wash well in the ordinary way and finally rinse in a

195.—CLEANSER

Strong solution of sodium bisulphite which will completely remove the brown colour.

Removing Developer Splashes from Clothes

Damp the spots or splashes with

196.—STAIN REMOVER

5% solution of potassium permanganate

Allow to remain for a few moments and then decolorise with

197.—CLEANSER

10% solution sodium bisulphite

In the case of *coloured cloth* or fabric care must be exercised, otherwise the treatment may cause the appearance of a bleached area.

Cleaning Solution for all Glass or Porcelain Vessels

198.—GLASS AND PORCELAIN CLEANSER

Water	...	...	...	...	40 ounces	1,000 c.cm.
Potassium dichromate	...	...	...	...	4 ounces	100 grams
Sulphuric acid conc.	...	...	...	...	4 ounces	100 c.cm.

Dissolve the dichromate first and then add the acid slowly and with constant stirring as great heat will be evolved. When this solution has been used the vessels must be well washed with plenty of water.

Releasing Jammed Glass Stoppers

Quickly but carefully *warm* the neck of the bottle with a *gas or spirit lamp flame*. Then *tap* the stopper with a *piece of wood* until loosened. Where the jamming of the stopper is due to *crystallising* of salts out of solution a *drop or two of water* is a help, or the bottle may be inverted and placed in *warm water* up to the neck of the bottle.

Disinfecting of Wood and Composition Tanks

Large tanks often develop a *black deposit* after some time in use, which harbours *bacteria* and causes *evil smelling gas* to be given off. Such tanks can be disinfected as follows.

199.—DISINFECTANT

Remove all metal parts such as hangers, rods and the like, then fill the tank with water, add a quart (1 litre) of commercial hydrochloric acid, stir in about 4 ounces (100 grams) chloride of lime.

Put the lid on the tank and leave it *overnight*, preferably out of doors. Next day empty the tank and *wash out* well with plenty of water.

Saving Cracked or Broken Negatives

(1) *The Film Is Undamaged*: It should be separated from the glass as follows. Harden the film for 15 minutes in

200.—HARDENING BATH

10% solution of formalin in water

Then with a sharp *knife* cut round the edge of the film about 1/16th-inch (2 mm.) inside the edge of the plate, *wash* the plate free from formalin solution and place in a dish with the following:

201.—PLATE STRIPPING SOLUTION

Water	...	...	...	...	4 ounces	100 c.cm.
Ammonium bifluoride	...	...	...	...	40 grains	2 grams
Sulphuric acid, 10% solution	...	...	...	...	5 drops	5 drops

After about *two minutes* the film can usually be stripped off the glass. It is *washed* carefully in water and floated on to another plate. If preferred, the new plate can be a plain *fixed but undeveloped*, in which case the gelatine film holds the stripped film firmly.

(2) *The Film is Damaged*: In this case the broken pieces must be cemented together, either with

202.—CEMENTS

Water glass or canada balsam thinned down with benzol

The broken pieces of glass have their edges painted with the cement and are then carefully fitted together on a glass plate and allowed to dry.

Giving Greater Transparency to Paper Negatives

The back of the negatives should be well rubbed with a very *thin clear machine oil* of the kind used for typewriters or sewing machines. If necessary the oil can be thinned with a little clear *paraffin oil*. Care should be taken not to use any excess of oil beyond that required to render the negative transparent. *Warming* helps.

Writing on Negatives

(1) *To Reproduce Clear Writing on Dark Ground*: On a well-gelatined strip of paper write the necessary text with a

203.—WRITING SOLUTION

Concentrated solution of potassium ferricyanide

and allow it to dry. Then *damp* the negative surface by soaking, remove all superfluous *moisture* and lay the gelatined paper on the negative with the writing against the negative film; leave for *one minute* and then remove and wash.

(2) *To Reproduce Black Lettering on the Negative*: The necessary text is written in *waterproof ink* on thin *cellophane* or *celluloid* which is then cemented on to the negative with the written side in contact with the negative film.

DEFECTS IN NEGATIVES

Faults in the Gradation of the Negative

(1) The negative lacks detail in the shadows and density in the high lights.

The usual cause is under-exposure (p. 30).

If there is perceptible detail in the shadows, then some improvement may be effected by intensification (p. 238).

(2) The negative is thin and flat, but there is reasonable detail in the shadows.

The negative has been correctly exposed but has been under-developed.

(a) Development was too short (p. 96).

(b) The developer was exhausted or too heavily diluted (p. 97).

(c) The temperature of the developer was too low (p. 99).

Intensification or the choice of a hard gradation paper, or both, should produce reasonably satisfactory pictures (p. 238).

(3) The gradation of the negative is flat and the shadows fogged. The parts of the plate or film protected from light, particularly the edges, are however clear.

The negative has been over-exposed. A somewhat similar fault develops in negatives of subjects taken against the light when parts of the subject have been too brilliantly lighted (p. 30).

The best remedy is the choice of a hard printing paper (p. 228). Where a shorter exposure, either for printing or enlarging is desired, the use of Farmer's reducer for clearing the shadows will also help by increasing the general contrast (p. 231).

(4) The negative is hard and has heavy, dense high lights.

It has been over-developed.

(a) Development was carried on for too long.

(b) The developer was too strong or contained too much alkali.

(c) The temperature of the developer was too high.

Choose a soft paper (p. 228) or use a superproportional reducer, i.e., ammonium persulphate, or both (p. 233).

(5) The negative is hard as in (4) and the shadows are fogged.

The negative has been over-exposed (p. 30) and also over-developed (p. 33).

A soft paper should be used, but the shadows should first be cleared with Farmer's reducer (p. 231) and then the whole negative reduced with persulphate (p. 233).

The Negative is Fogged

(6) The negative shows grey fog all over, including those parts protected from light by the rebate of camera or dark-slide.

(a) Development is too long or too warm developer or lack of bromide (p. 69).

(b) Unsafe dark-room light, or stray white light in dark-room (p. 113).

Test safelight to ensure that it is suitable for the negative material being used (p. 115-116).

(c) Faulty sensitive material due to staleness, inappropriate storage, etc.

(d) Aerial fog due to too much exposure to air during development; this can occur particularly in drum-development (p. 103), and when dish-development is used (p. 97).

Desensitisation helps to reduce this possibility (p. 205).

Use of a hard printing paper (p. 228) may help, also clearing the fog with Farmer's reducer (p. 231) followed later by intensification (p. 238).

(7) The edge of the plate or film shows a black fog which tails off towards the inside of the plate or film.

(a) Manufacturing fault or stale material, more common in plates than film.

(b) In roll-film can occur through a loosely-wound spool being exposed to daylight during charging or emptying the camera.

(8) Dichroic fog appears red or violet by transmitted light and bluish or green by reflected light.

(a) Spent developer or developer contaminated with hypo (p. 210).

(b) Developer too warm (p. 83) or development too protracted. With fine-grain developers too high a sulphite content can cause the trouble (p. 143).

(c) Exhausted fixing bath, or fixing bath too warm and spent (p. 215).

(d) Fixing bath contains too much carried over developer (p. 210).

(e) Insufficient rinse between development and fixing, or exhausted stop-bath (p. 210).

(f) Negative exposed to white light before fixing was complete.

(9) The negative shows yellow fog when examined by transmitted light.

Causes similar to those detailed under dichroic fog.

Removal of yellow and dichroic fog.

1st Method: Harden the emulsion film in the following bath

204.—HARDENING BATH

Formaline	...	...	...	...	$\frac{1}{2}$ ounce	12 c.cm.
Sodium carbonate, anhyd.	...	...	...	...	$\frac{1}{4}$ ounce	6 grams
Water up to	...	...	...	...	40 ounces	1,000 c.cm.

Then wash for a moment or two and treat for 5 minutes in a half per cent solution of potassium permanganate, wash, fix in 30 per cent plain hypo, clear in 10 per cent bisulphite and wash finally.

2nd Method: Bathe the negative in the following solution.

205.—FOG REMOVER

Thiourea	...	...	...	...	28 grains	1.4 grams
Citric acid	...	...	...	...	28 grains	1.4 grams
Water to make	...	...	...	...	5 ounces	125 c.cm.

(10) Yellow fog which merges into brown.

Caused by oxidation products in the developer, usually due to too low sulphite content (p. 159). It may also occur when a fixing bath is exhausted and contaminated with developer (p. 210).

To remove the fog harden the negative in the formalin bath given above, wash, bleach in the permanganate bleach made up as follows. Make up a solution containing:

206.—FOG REMOVER

Sodium chloride (common salt)	...	...	...	1 ounce	7 grams
Sulphuric acid conc.	...	...	...	20 minims	1.5 c.cm.
Water	...	...	...	4 ounces	100 c.cm.

Add to this just before use 4 ounces (100 c.cm.) of half per cent solution of permanganate. Bleach for 3-4 minutes; the film will become covered with brown manganese dioxide which, after a good rinse, is removed by sodium bisulphite solution. Now wash the negative well and place in full daylight until it assumes a reddish colour and then re-develop it, using the amidol developer recommended by Kodak.

207.—AMIDOL RE-DEVELOPER

Water at 125°F. (52°C.)	...	...	...	30 ounces	750 c.cm.
Sodium sulphite, anhyd.	...	...	...	1 ounce	25 grams
Amidol	...	...	...	1 ounce	6.5 grams
Cold water to make	...	...	...	40 ounces	1,000 c.cm.

(11) The negative shows a red, blue or greenish coloration.

Usually caused by the anti-halo layer (p. 49).

The colouring can easily be removed by a weak alkaline solution, e.g., a diluted developer or water containing a few drops of ammonia.

White Deposit On or In the Film of the Negative

(12) Fine-grained white deposit.

Chalky residue from very hard water (p. 71).

Use calgon or similar compound in developer (p. 72).

Remove deposit by bathing negative in 2 per cent acetic acid, then wash well. If this treatment causes a coloration of the negative, add a few drops of ammonia to the wash water.

(13) Whitish deposit on the dried negative, which has a shiny appearance when wet.

The deposit consists of aluminium sulphite derived from a hardening and fixing bath into which too much developer has been carried over.

The use of an acid stop bath helps here and lengthens the life of the hardening fixing bath (p. 210). To remove the deposit, harden the film in alkaline formalin solution (p. 280), and then treat the film in a 5 per cent solution of sodium carbonate, then wash well.

(14) Pale yellowish-white appearance of negative. Opalescence.

Due to decomposition of fixing bath and setting free of sulphur. The fixing bath contains too much acid, too little sulphite or is too warm (p. 211).

To remove the opalescence harden the film in alkaline formalin solution (p. 280), wash well and treat with a 10 per cent solution of sodium sulphite at a temperature of about 100°F. (38°C.).

Dark or Light Streaks or Blotches on the Negative

(15) Light or dark parallel streaks appearing, light streaks on dark parts and dark streaks on light parts of negative.

Due to insufficient movement of developer during development, allowing local concentration of used-up developer (p. 110).

(16) Dark or light streaks originating where the plate or film holder touched the negative material.

Dirty plate or film holder.

See p. 275 for cleaning.

(17) Scum markings.

Dirty developer due to dust, etc.

(18) Large irregular light areas with sharp edges.

Unequal flow of developer over negative so that development was uneven (p. 99).

(19) Regular wave-like markings on negatives dish developed.

Insufficient rocking of dish during development (p. 99).

(20) Sharply-defined areas of varying density.

Too small an amount of developer in dish also same as (18).

(21) Irregular areas of higher density.

Variations in concentration of developer can be caused by adding concentrated or warm developer to tank or dish during development. This should never be done.

(22) Irregularly-defined light areas, often contaminated with scum.

Due to developer standing in tank unprotected from dust and air. The surface becomes covered with a scum of oxidation products which gets on to the surface of the negative and locally hinders development.

If such scum is seen on the surface of the developer it should be carefully removed by means of a sheet of filter or blotting paper.

Spots, Flecks and Linear Markings

(23) Thin black or light straight lines.

Scratches due to abrasion. Often caused on roll film by dust or grit getting into the camera, or by careless loading of spools causing the film to jam when being wound through the camera. If the scratches are made before exposure they usually appear light; if after exposure then darker than their surroundings.

(24) Black irregular forked or branched wavy lines.

Static markings caused by an electric charge being developed on the film. Usually caused in manufacture, but can occur in very cold and dry areas, if the film is carelessly handled and roughly wound up.

(25) Strong black lines usually radiating from a corner or side of negative.

Light leaks either in the front or the bellows of the camera.

(26) Small, light, undefined brownish flecks.

Over-used and insufficiently agitated tank developer (p. 110).

(27) Marbling-like or honeycomb markings on the film.

Exhausted insufficiently mixed or unstirred developer (p. 82).

(28) Clear, well-defined light round spots, sometimes with comet-like tail.

Air bells on the film during the early stages of development (p. 99).

(29) Honeycomb markings with dark surrounds.

Scum on the developer which has collected on the face of the negative.

(30) Wrinkled film or reticulation.

Too great a variation in temperature between baths, usually too high a developer temperature followed by a cold fixing bath.

(31) Small light or dark spots usually well defined.

Ordinary or chemical dust which has settled on the negative before development.

(32) Small dark or light flecks of irregular form.

Particles of undissolved chemicals in the developer.

(33) Holes in the film or hollows.

A fault caused by bacteria or moulds, most common in summer when plates or films have been too long drying in a warm, moist atmosphere.

(34) Light or dark drop-like markings on the film.

(a) Spots of water which have fallen on a partially dry negative.

(b) Drops of water left on a negative when put to dry (p. 226).

Less Common Negative Faults

(35) Small blisters covering the negative.

Usually caused by carbonic acid gas set free when the negative is transferred from the developer to a stop bath or an acid fixing bath.

(36) Wrinkled emulsion at edges or film floating off support.

Too high temperature developer (p. 83) or wide differences in the temperature of the different baths.

(37) The numbers and other indications from the red or green-black paper of the roll-film appear as a developed image on the film.

Badly stored or stale film.

(38) Partial or complete reversal of the negative into a positive image.

Use of unsafe dark-room lighting (p. 113) or accidental fogging with white light before exposure.

(39) Partial melting of film during drying.

Too high a drying temperature (p. 226) and not sufficient air current.

The illustrations of defects in negatives on pages 278-285 have been contributed by the *Eastman Kodak Company*, Rochester, (U.S.A.), the *Gevaert Factories*, Antwerp, (Belgium), and *Ilford Limited*, London.

PHOTOGRAPHIC CHEMICALS

In the following pages, details are given of the more important photographic chemicals and are arranged as follows.

(1) The common *name* of the chemical, other names in use and chemical composition.

(2) *Appearance, method of preserving, special properties*, i.e., poisonous, corrosive or inflammable. *Solubility* in water at normal temperature (in case of developing agents in parts per 100=WS.). In the case of developing agents there is also given (a) Solubility in 100 parts 10% sodium sulphite solution S.S.S. and (b) Solubility in 100 parts of a mixture of equal volumes of sodium sulphite $\frac{1}{2}\%$ and sodium carbonate $\frac{1}{2}\%$ solutions, S.S.C., also at normal temperature, i.e., 65° F. (18° C.).

(3) Use for photographic purposes, usually with page references.

ACETIC ACID GLACIAL. CH_3COOH .

Water clear fluid with stinging smell. Solidifies at low temperatures (below 50°F. (10°C.)). Corrosive action; keep in glass-stoppered bottle.

Mixes in all proportions with water.

Used for stop bath (p. 210), addition to fixing baths (p. 211) and in uranium intensifier (p. 257).

ALUM. POTASH. Aluminium potassium sulphate. Rock alum. $\text{K}_2\text{Al}_2(\text{SO}_4)_4 \cdot 24\text{H}_2\text{O}$.

Colourless transparent crystals or white powder. Corked bottle.

Solubility 1 part in 10-11 parts water.

Used as hardening agent (p. 213), also in hypo-alum toning. (See Jacobson: "Enlarging," p. 235.)

ALUM CHROME. Chromium potassium sulphate. $\text{K}_2\text{Cr}_2(\text{SO}_4)_4 \cdot 24\text{H}_2\text{O}$.

Deep violet crystals. Corked bottle.

Soluble 1 part in 5-7 parts water.

Used as hardening agent in hardening fixing baths (p. 213).

AMIDOL. 2,4-Diamino-phenol hydrochloride. $\text{C}_6\text{H}_3(\text{OH})(\text{NH}_2)_2 \cdot \text{HCl}$.

White to greyish needle crystals. Keep in brown glass bottle with well-waxed cork.

WS. 25 parts. SSS. 28 parts. SSC. 26 parts.

Strong developer without alkali (p. 78).

AMMONIA. Liquid ammonia. NH_4OH .

Colourless solution of ammonia gas in water, with penetrating smell. .880 ammonia contains 35% NH_3 . .910 ammonia contains 25% NH_3 . Corrosive and poisonous. Keep in glass-stoppered bottle.

Used in reversal developers (p. 180), and as blackening agent in intensifying (p. 240).

AMMONIUM CARBONATE. Lump ammonia. $(\text{NH}_4)_2\text{CO}_3$.

White lumps or powder, ammoniacal smell. Keep in glass-stoppered bottle.

Soluble 1 part in 4 parts water.

Used in special developers.

AMMONIUM CHLORIDE. Sal ammoniac. NH_4Cl .

White crystalline powder, keep in corked bottle.

Soluble 1 part in 3 of water.

Used in preparing quick fixing baths (p. 215).

AMMONIUM BIFLUORIDE. Acid ammonium fluoride. $\text{NH}_4\text{F.HF}$.

White powder. Attacks the skin, poisonous. Glass bottle with waxed cork.

Easily soluble in water.

Used for removing gelatine emulsion film from glass plates (p. 276).

AMMONIUM PERSULPHATE. $(\text{NH}_4)_2\text{S}_2\text{O}_8$.

Colourless crystals. Glass-stoppered bottle.

Soluble 1 part in 1.7 parts of water.

As reducer (p. 233), also as hypo eliminator (p. 225).

BORAX. Sodium baborate. $\text{Na}_2\text{B}_4\text{O}_7.10\text{H}_2\text{O}$.

White powder or crystals. Corked bottle.

Soluble 1 part in 17 water.

As mild alkali in fine-grain developers (p. 143).

BORIC ACID. Boracic acid. H_3BO_3 .

White lamellar crystals, greasy feel. Corked bottle.

Solubility 1 in 25 water.

As addition to fine-grain developers (p. 146).

CALGON. Presumably sodium hexa-metaphosphate.

White powder or colourless crystals. Corked bottle.

As preventative to precipitation of calcium salts in hard water.

COPPER SULPHATE. Blue vitriol. $\text{CuSO}_4.5\text{H}_2\text{O}$.

Blue crystals, caustic and poisonous, corked bottle.

Soluble 1 part in 3 water.

As bleach bath (p. 236), and as intensifier (p. 261).

CHLORQUINOL. Mono-chlor-hydroquinone, Adurol. $\text{CLC}_6\text{H}_3(\text{OH}_2)$.

Greyish crystalline powder.

Very soluble in water

Used as developer (p. 130).

CITRIC ACID. $\text{C}_6\text{H}_8\text{O}_7.\text{H}_2\text{O}$.

Colourless crystals, corked bottle.

Soluble 1 part in 0.75 water.

In silver intensifier (p. 261).

- FORMALINE.** Solution of gaseous formaldehyde in water. $\text{H}\cdot\text{CHO}$.
Water clear but faintly yellowish solution, poisonous with unpleasant smell. Vapour dangerous to light sensitive material. Brown glass-corked bottle.
Miscible in all proportions with water.
As hardening agent when diluted with water (p. 280).
- GLYCERINE.** Glycerol. $\text{C}_3\text{H}_5(\text{OH})_3$.
Colourless thick fluid. Corked bottle.
Miscible in all proportions with water.
As softening agent and in enlarging scratched negatives. (See Jacobson: "Enlarging," p. 246).
- GLYCIN.** Iconyl. Athenon. Paraoxyphenyl glycin. $\text{C}_6\text{H}_4\text{OH}\cdot\text{NH}\cdot\text{CH}_2\cdot\text{COOH}$.
White crystals. Brown glass bottle with well-waxed cork.
WS. 0.23. SSS. only traces. SSC, $12\frac{1}{2}$ parts.
Slow and very clean-working developer (p. 77).
- HYDROCHLORIC ACID.** Muriatic acid. Spirits of salts. HCl .
Colourless when pure, but often yellowish. Corrosive and poisonous. Vapour dangerous to photographic materials. Glass-stoppered bottle.
In bleach baths (p. 258), also for cleaning dirty vessels.
- HYDROQUINONE.** Quinol. Paradihydroxybenzene. $\text{C}_6\text{H}_4(\text{OH})_2$.
Colourless crystals. Brown glass bottle with well-waxed cork.
WS. $5\frac{1}{2}$ -6. SSS. 4. SSC. $7\frac{1}{2}$.
Widely used developer (p. 75).
- IRON ALUM.** Iron ammonium sulphate. $\text{Fe}_2(\text{NH}_4)_2(\text{SO}_4)_4\cdot 24\text{H}_2\text{O}$.
Pale violet crystals. Brown glass corked bottle.
Soluble 1 part in 7 water.
For blue toning (p. 236).
- IRON CHLORIDE.** Ferric chloride. $\text{Fe}_2\text{Cl}_3\cdot 6\text{H}_2\text{O}$.
Yellow masses. Brown glass-stoppered bottle.
Very soluble in water 1 in 0.6.
Used in Belitzki's reducer (p. 232).
- MERCURY CHLORIDE.** Mercuric chloride. Corrosive sublimate. HgCl_2 .
White crystals. Violent poison. Glass-stoppered bottle.
Soluble 1 in 16 water.
Used in mercury intensifier (p. 240).
- MERITOL** understood to be paraphenylenediamine pyrocatecholate $\text{C}_6\text{H}_4(\text{NH}_2)_2\cdot\text{C}_6\text{H}_3(\text{OH})_2$.
Cream or greyish crystalline substance.
Used in fine-grain developers (p. 152).
- METOL.** Elon. Pictol. Genol. Rhodol. Methyl para-aminophenol sulphate. $\text{C}_6\text{H}_4(\text{OH})(\text{NH}\cdot\text{CH}_3)\frac{1}{2}\text{H}_2\text{SO}_4$.
Colourless needles or prisms. Brown glass bottle with well-waxed cork.
WS. 5. SSS. 2. SSC. $4\frac{1}{2}$.
Developer of universal applicability (p. 74).

PARA-AMINOPHENOL HYDROCHLORIDE. $C_6H_4(NH_2)(OH) \cdot HCl$.

Colourless crystals. Brown glass bottle with waxed cork.

WS. 33. SSS. —. SSC. 3.

Rapid developer in alkali solution (p. 77). Basis of many commercial concentrated developers: Azol, Rodinal, Certinal, etc.

PARAPHENYLENEDIAMINE. 1,4-Diaminobenzene. $C_6H_4(NH_2)_2$.

White to brownish powder. Poisonous. Brown glass bottle with waxed cork.

Used in fine-grain developers (p. 78).

PHENYLENEDIAMINE ORTHO. 1,2-Diaminobenzene. $C_6H_4(NH_2)_2$.

White crystals. More stable than paraphenylenediamine. Brown glass bottle with waxed cork.

For fine-grain developers (p. 79).

POTASSIUM BROMIDE. KBr .

White cubic crystals or white powder. Corked bottle.

Soluble 1 in 1.6 water.

Restraint in developers (p. 69), also in bleaching baths.

POTASSIUM CARBONATE. Potash. K_2CO_3 .

White powder, attracts moisture with avidity. Glass bottle with rubber stopper.

Soluble 1 in 1 water.

Alkali for developers (p. 64), and as quick-drying medium.

POTASSIUM DICHROMATE. Bichromate of potash. $K_2Cr_2O_7$.

Orange red crystals, poisonous. Corked bottle.

Soluble 1 part in 10 water.

In reversal baths (p. 180), also for cleaning vessels (p. 275).

POTASSIUM FERRICYANIDE. Red prussiate of potash. $K_3Fe(CN)_6$.

Dark red crystals, poisonous. Corked bottle.

Soluble 1 in 2.5 water.

As reducer (p. 231), and in bleach baths (p. 259).

POTASSIUM HYDROXIDE. Caustic potash. KOH .

Appears in sticks, flakes and pellets, strongly corrosive and attracts moisture. Bottle with rubber stopper.

Extremely soluble in water, 1 in 0.5.

Strong alkali for developers (p. 64).

POTASSIUM IODIDE. KI .

White cubic crystals. Brown glass-corked bottle.

Soluble 1 in 0.7 water.

As addition to developer (p. 70), and for mercuric iodide intensifier (p. 257).

POTASSIUM METABISULPHITE. $K_2S_2O_5$.

Colourless, hard crystals. Corked bottle.

Soluble 1 in 3 water.

As preservative in developers (p. 61), stop bath (p. 210), as acidifier in fixing baths (p. 212), as clearing bath (p. 196).

POTASSIUM PERMANGANATE. $KMnO_4$.

Glistening violet black crystals. Corked bottle.

Soluble 1 in 16 water.

As reducer (p. 232), hypo eliminator (p. 225), reversal baths (p. 194).

POTASSIUM SULPHOCYANIDE. Potassium thiocyanate. Potassium rhodanate. KCNS .

Colourless crystals, poisonous. Brown glass-stoppered bottle.

Soluble 1 in 0.5 water.

Addition to fine-grain developers (p. 147).

PYROCATECHIN. Pyrocatechol. Orthodioxycbenzene. $\text{C}_6\text{H}_4(\text{OH})_2$.

White crystals. Brown glass bottle with waxed cork.

Developer (p. 76).

WS. 33. SSS. —. SSC. 36.

PYROGALLOL. Pyro. Pyrogallie acid. Trioxybenzene. $\text{C}_6\text{H}_3(\text{OH})_3$.

Colourless crystals, poisonous. Brown glass bottle and waxed cork.

WS. 52. SSS. 59. SSC. 42.

Developer (p. 77).

SILVER NITRATE. Lunar caustic. AgNO_3 .

Colourless crystals, poisonous and strong caustic. Brown glass-stoppered bottle.

Soluble 1 in 1 water.

Physical development (p. 156), intensification (p. 261).

SODIUM BISULPHITE. NaHSO_3 .

White crystalline powder. Sulphurous acid smell. Glass-stoppered bottle.

Soluble 1 in 4 water.

Used for same purposes as potassium metabisulphite.

SODIUM BISULPHITE LYE. Average density 36° Baume = 1.33 sp. G.

Colourless or pale yellow fluid. Glass bottle with rubber stopper.

Used for same purpose as sodium bisulphite (p. 60).

SODIUM CARBONATE. Soda. Carbonate of soda. Na_2CO_3 and $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$.

White crystals or powder. Corked bottle. Crystal carbonate.

Soluble 1 in 1.6 water, anhydrous 1 part in 6 water.

Used as alkali in developers.

SODIUM CHLORIDE. Common salt. NaCl .

White powder. Corked bottle.

Soluble 1 in 2.5 water.

Addition to mercury intensifier and copper bleach bath (p. 236).

SODIUM HYDROXIDE. Caustic soda. NaOH .

In sticks, flakes and pellets, strong caustic. Glass bottle with rubber stopper.

Soluble 1 in 1.7 water. (Generates heat on dissolving as does caustic potash.)

Strong alkali for developers (p. 64).

SODIUM METAPHOSPHATE. $\text{Na}_4\text{P}_4\text{O}_{12}$.

White powder. Corked bottle.

Soluble 1 in 2 water.

Prevents precipitation of lime salts in hard water (p. 71).

SODIUM PHOSPHATE, TRIBASIC. $\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$.

White crystals. Corked bottle.

Soluble 1 in 5 water.

As mild alkali in developers (p. 143).

SODIUM SULPHATE. Glaubers salts. $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$.

- Colourless crystals. Corked bottle.
Soluble 1 in 2 water.
As addition to tropical developer (p. 164).
- SODIUM SULPHIDE.** $\text{Na}_2\text{S}\cdot 9\text{H}_2\text{O}$.
Colourless crystals, somewhat corrosive. Brown glass bottle with rubber stopper.
Very soluble in water.
Used in intensifying (p. 238), and toning (see Jacobson: "Enlarging," p. 235).
- SODIUM SULPHITE.** $\text{Na}_2\text{SO}_3\cdot 7\text{H}_2\text{O}$.
White powder or crystals. Corked bottle.
Anhydrous salt soluble 1 in 5 water.
Preservative in developers (p. 59), as blackening agent (p. 240).
- SODIUM THIOSULPHATE.** Hypo. Sodium hyposulphite. $\text{Na}_2\text{S}_2\text{O}_3\cdot 5\text{H}_2\text{O}$.
Colourless crystals. Corked bottle.
Soluble 1 in 0.7 water.
The universal fixing material (p. 209).
- SULPHURIC ACID.** Oil of vitriol. H_2SO_4 .
Colourless oily liquid. Strong corrosive and poisonous. Glass-stoppered bottle.
Caution: When dilute acid is required, the acid must always be poured into the water, never the reverse, otherwise the reaction attains explosive violence.
Used for bleach baths (p. 236), cleaning solution (p. 275).
- SULPHUROUS ACID.** H_2SO_3 .
Colourless fluid with strong smell of burning sulphur.
Freely soluble in water.
For high speed developers (p. 169).
- URANIUM NITRATE.** Uranyl nitrate. $\text{UO}_2(\text{NO}_3)_2\cdot 6\text{H}_2\text{O}$.
Yellowish crystals. Poisonous. Glass-stoppered bottle.
Soluble 1 in 0.5 water.
Used in uranium intensifier (p. 257).

SUBSTITUTE CHEMICALS

Substitute for Metol

Metol cannot be replaced except by changing the whole formula, as follows :

208.—UNIVERSAL DEVELOPER WITHOUT METOL

Para-Aminophenol Hydrochloride or

-Oxalate	...	...	...	30 grains	1.5 grams
Hydroquinone	...	...	...	40 grains	2 grams
Sodium sulphite anhyd.	...	...	...	2 ounces	50 grams
Caustic soda	...	...	...	60 grains	3 grams
Potassium bromide	...	...	...	50 grains	2.5 grams
Water to make	...	...	...	40 ounces	1,000 c.cs

Dissolve the caustic soda separately in a small quantity of water then add the solution containing the other constituents already dissolved.

Substitute for Potassium Salts

Potassium compounds are in short supply and difficult to obtain. All published formulae in this book, however, prescribe the use of sodium carbonate as an alkali, so there will be no difficulties in this respect. Sodium carbonate, instead of potassium carbonate can also be freely used in formulae from other sources, provided that equivalent quantities are used :—13 parts by weight of potassium carbonate are equal to 10 parts by weight of sodium carbonate.

When making up developing formulae, bleaching baths, etc., the equivalent by weight of sodium bromide may be used instead of potassium bromide.

As already mentioned on p. 212, sodium bisulphite can replace potassium metabisulphite in fixing baths.

New Stop-Bath and Fixing-Bath Formulae

Investigations have been carried out by the Kodak Research Laboratories with a view to replacing the ordinarily used chemicals—which may not now always be obtainable—in the production of stop-baths and fixing-baths.

Tests have indicated that for acid stop-bath purposes a variety of acidic compounds may be substituted for the *acetic acid* usually employed, namely, a mixture of *sodium acid sulphate* or *sulphuric acid* and *sodium acetate*; *citric acid*; *sodium bisulphite* or *potassium metabisulphite*.

An almost identical substitute for an acetic acid stop-bath can be compounded from *sodium acetate* and an acidic substance such as *sodium acid sulphate* or *sulphuric acid*:

209.—KODAK SB-8 STOP-BATH

Water	...	...	...	80 ounces	500 cc.
Sodium acetate (desiccated)	...	...	...	3 ounces 88 grains	20 grams
Sodium acid sulphate	...	...	...	6 ounces 175 grains	40 grams
Water to make	...	...	...	1 gallon	1,000 cc.

(For sodium acid sulphate may be substituted alternatively 5 per cent sulphuric acid, at the rate of 28 fluid ounces for the gallon batch, or 175 cc. for the 1,000 cc. quantity. To make 5 per cent sulphuric acid, add slowly 1 part by volume of pure concentrated sulphuric acid to 19 parts by volume of cold water, and mix carefully by stirring. The acid must be added slowly to the water and not the water to the acid, otherwise the solution may boil with explosive violence.)

In the case of highly alkaline developers a somewhat more concentrated acid stop-bath is necessary, which should preferably be used only in conjunction with Kodalk or caustic developers in order to avoid blistering. The stop-bath should likewise be followed by a short water rinse.

210.—KODAK SB-8a STOP-BATH

Water	...	...	...	80 ounces	500 cc.
Sodium acetate (desiccated)	...	...	...	8 ounces	50 grams
Sodium acid sulphate	...	...	...	1 lb.	100 grams
Water to make	...	...	...	1 gallon	1,000 cc.

(For sodium acid sulphate may be substituted alternatively 5 per cent sulphuric acid, at the rate of 70 fluid ounces for the gallon batch, or 440 cc. for the 1,000 cc. quantity. For the preparation of 5 per cent sulphuric acid see footnote to Formula SB-8 above.)

A 1.5% solution of citric acid constitutes a very satisfactory acid stop-bath, although if an excess is carried over into the fixing bath it tends to impair the hardening properties of the latter. When exhausted the bath should be discarded and a fresh bath prepared. Suitable formulae are :

211.—KODAK SB-7 STOP-BATH

Citric acid	...	...	...	2 ounces	175 grains	15 grams
Water to make	...	...	...	1 gallon		1,000 cc.

212.—KODAK SB-7a STOP-BATH

Citric acid	...	...	...	6 ounces		37½ grams
Water to make	...	...	...	1 gallon		1,000 cc.

The hardening and anti-sludging properties of acid hardening fixing baths containing acetic and boric acids cannot be duplicated by other readily available acids. Acetic acid, however, can be replaced satisfactorily by sodium acetate in combination with another acidic compound such as sodium bisulphite or sodium acid sulphate :

213.—ACID HARDENING FIXING BATH WITH SODIUM ACID SULPHATE

Water, 125°F.	...	...	...	80 ounces		500 cc.
Sodium thiosulphate	...	...	...	2½ lbs.		240 grams
Sodium bisulphite	...	...	...	2½ ounces		15 grams
Boric acid	...	...	...	1½ ounce		7.5 grams
Sodium acetate anhydrous	...	...	...	3½ ounces		20 grams
Sodium acid sulphate (20% sol )	...	...	...	12 fluid ounces		75 cc.
Potassium alum	...	...	...	2½ ounces		15 grams
Water to make	...	...	...	1 gallon		1,000 cc.

(To make a 20% solution of sodium acid sulphate, dissolve 200 grams (8 ounces) of sodium acid sulphate in 750 cc. (30 ounces) of water and add cold water to make 1 litre (40 ounces). The sodium acid sulphate must be added slowly and as a solution, otherwise the fixing bath will sulphurise. If boric acid is not available, one third the quantity of Rochelle Salts (sodium potassium tartrate) may be used instead, though there will be some loss in respect of hardening properties and resistance to precipitation.)

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